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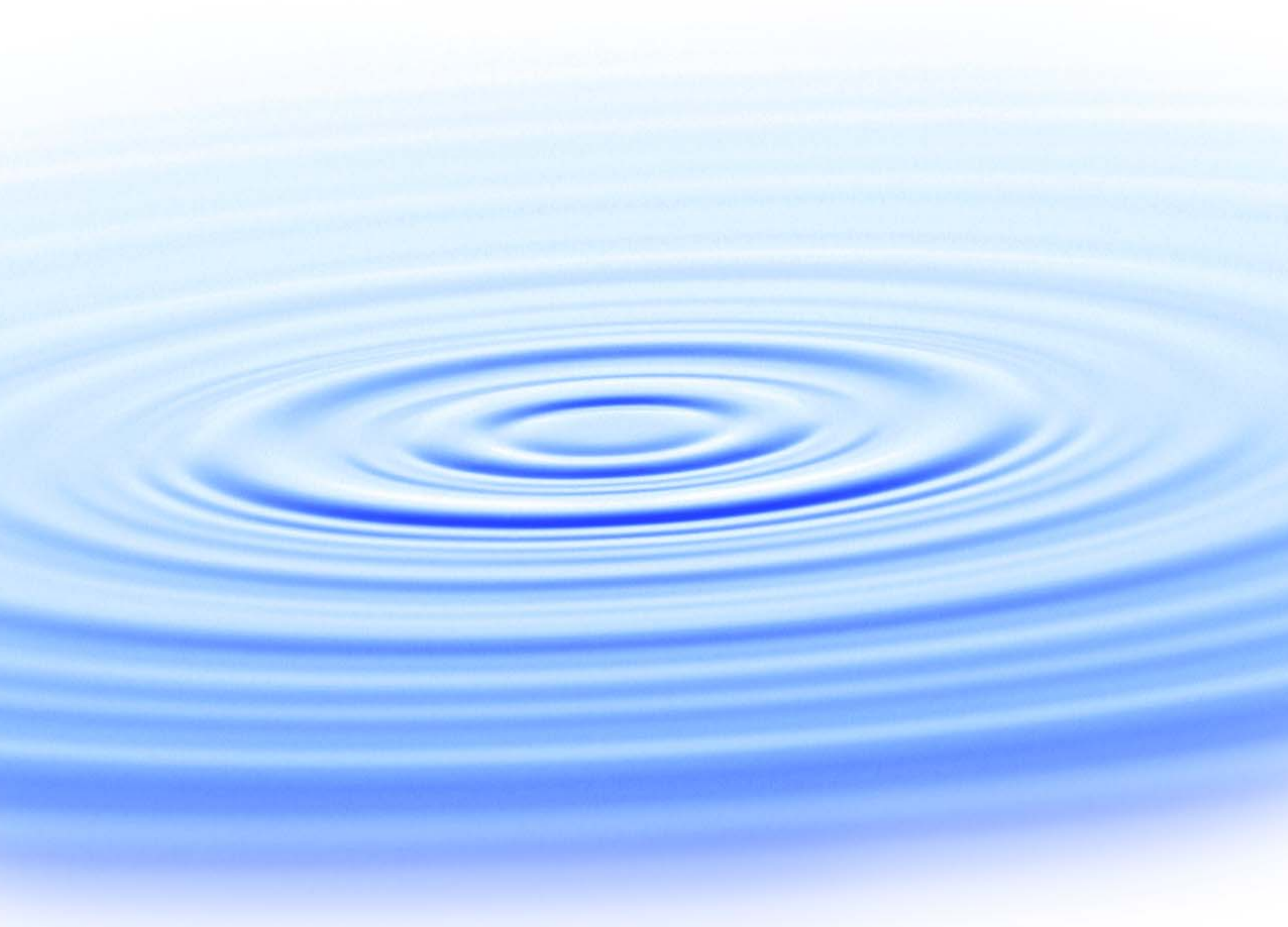
BUREAU OF RECLAMATION

WATEREUSE RESEARCH

# The Value of Water Supply Reliability in the Residential Sector



WateReuse Research Foundation

# The Value of Water Supply Reliability in the Residential Sector

## About the WateReuse Research Foundation

The mission of the WateReuse Research Foundation is to conduct and promote applied research on the reclamation, recycling, reuse, and desalination of water. The Foundation's research advances the science of water reuse and supports communities across the United States and abroad in their efforts to create new sources of high-quality water through reclamation, recycling, reuse, and desalination while protecting public health and the environment.

The Foundation sponsors research on all aspects of water reuse, including emerging chemical contaminants, microbiological agents, treatment technologies, salinity management and desalination, public perception and acceptance, economics, and marketing. The Foundation's research informs the public of the safety of reclaimed water and provides water professionals with the tools and knowledge to meet their commitment of increasing reliability and quality.

The Foundation's funding partners include the Bureau of Reclamation, the California State Water Resources Control Board, the California Energy Commission, and the California Department of Water Resources. Funding is also provided by the Foundation's Subscribers, water and wastewater agencies, and other interested organizations.

# The Value of Water Supply Reliability in the Residential Sector

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## Disclaimer



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# Acronyms

| | |
|---|---|
| ABM | attribute-based method |
| ASR | aquifer storage and retrieval |
| BT | benefits transfer |
| CII | commercial, industrial, and institutional |
| CPI | Consumer Price Index |
| CUWA | California Urban Water Agencies |
| desal | desalination |
| DOI | U.S. Department of the Interior |
| EPA | U.S. Environmental Protection Agency |
| GWRS | Groundwater Replenishment System |
| IPR | indirect potable reuse |
| KN | Knowledge Networks |
| LBWD | Long Beach Water Department |
| MWD | Metropolitan Water District of Southern California |
| NED | National Economic Development |
| NOAA | National Oceanic and Atmospheric Administration |
| NRC | National Research Council |
| OMB | Office of Management and Budget |
| OUC | Orlando Utilities Commission |
| RUM | random utility maximization |
| SASE | standard annual shortage event |
| SFPUC | San Francisco Public Utilities Commission |
| SWP | State Water Project |
| WTA | willingness to accept |
| WTP | willingness to pay |

# Foreword

The WateReuse Research Foundation, a nonprofit corporation, sponsors research that advances the science of water reclamation, recycling, reuse, and desalination. The Foundation funds projects that meet the water reuse and desalination research needs of water and wastewater agencies and the public. The goal of the Foundation's research is to ensure that water reuse and desalination projects provide high-quality water, protect public health, and improve the environment.

An Operating Plan guides the Foundation's research program. Under the plan, a research agenda of high-priority topics is maintained. The agenda is developed in cooperation with the water reuse and desalination communities including water professionals, academics, and Foundation subscribers. The Foundation's research focuses on a broad range of water reuse research topics including:

- Defining and addressing emerging contaminants
- Public perceptions of the benefits and risks of water reuse
- Management practices related to indirect potable reuse
- Groundwater recharge and aquifer storage and recovery
- Evaluation and methods for managing salinity and desalination
- Economics and marketing of water reuse

The Operating Plan outlines the role of the Foundation's Research Advisory Committee (RAC), Project Advisory Committees (PACs), and Foundation staff. The RAC sets priorities, recommends projects for funding, and provides advice and recommendations on the Foundation's research agenda and other related efforts. PACs are convened for each project and provide technical review and oversight. The Foundation's RAC and PACs consist of experts in their fields and provide the Foundation with an independent review, which ensures the credibility of the Foundation's research results. The Foundation's Project Managers facilitate the efforts of the RAC and PACs and provide overall management of projects.

This report describes original stated preference survey research, using a choice experiment approach to assess the willingness to pay (WTP) of residential customers for more reliable water supplies in their communities. Residential customers consistently revealed a statistically significant WTP to improve the reliability of their water supply in order to avoid relatively severe water use restrictions. Households also expressed a clear and strong preference for expanding water recycling as a top option for enhancing water supply reliability.

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Inland Empire Utilities Agency (CA)
Irvine Ranch Water District (CA)
Long Beach Water Department (CA)
Las Vegas Valley Water District (NV)
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San Diego County Water Authority (CA)
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# Executive Summary

Water reuse and desalination (desal) offer reliable and locally controlled yields when drought, climate change, or other factors (e.g., court orders curtailing freshwater extraction) limit other water supply options. Utility managers and others recognize that this yield reliability is likely to be highly valued by their communities. However, the absence of suitable customer valuation data has made these reliability benefits difficult to quantify in a meaningful and credible manner. This impedes the implementation of reuse and desal and adds a challenge to securing state, federal, or other funding.

This project addresses this critical gap by developing estimates of the economic value of drought-resistant water yield reliability, such as that associated with reuse and desal projects. For the purposes of this research, we focus on reliability within the context of long-term water supply planning. This primarily includes planning for periodic (drought) events through the development of new supply sources.

The research team developed and implemented state-of-the-art "stated preference" surveys and statistical analyses to develop robust estimates of household willingness to pay (WTP) for water supply reliability. In this context, values for reliability were determined based on household WTP to avoid future water use restrictions (e.g., limitations on outdoor watering). These estimates can be used by water utilities when they evaluate and compare the benefits of future water supply options.

In addition to providing insight into how water utility customers value reliability, the stated preference surveys and subsequent analyses include information on the types of water supply options (including reuse and desal) that customers think their water utilities should pursue in the future to increase supply reliability.

The survey developed in this research effort was applied (with minor modifications to tailor it to local circumstances) to five water utility service areas across the United States: one anonymous North American utility (referred to throughout as "Utility X" or "City X"); Austin, TX; Long Beach, southern CA; Orlando, FL; and San Francisco, northern CA. The surveys were administered in the latter half of 2010 and the first half of 2011. Over 400 completed surveys were collected in each region, for a total sample size of over 2000 households.

Several empirical findings were consistently observed across the utility service areas in which customers were surveyed. Although these findings may not necessarily apply to customers in a specific utility, the consistency of findings across the five regions suggests that the preferences expressed may be consistently held in many geographical areas.

1. Residential customers consistently reveal a positive WTP to improve the reliability of their water supply in order to avoid relatively severe water use restrictions.

   The estimated WTP to avoid relatively severe ("Stage 2") water use restrictions was statistically significant in all five regions and ranged from $20.20 per household per year (Orlando) to $37.16 per household per year (San Francisco). These values reflect the WTP by households each year to avoid one year of Stage 2 restrictions at some point over the next 20 years. Given that the scenario evaluated in the survey reduced the projected number of Stage 2 restrictions by up to 3 years, the WTP to avoid all Stage 2 restrictions over the 20-year period ranged from $60.60 to $111.48 per household per year. These per household annual WTP values are consistent with the year-adjusted values derived by earlier WTP studies developed in the 1980s and 1990s.

2. Residential customers tend to view low-level ("Stage 1") water use restrictions as an acceptable inconvenience and generally express a low WTP to avoid such water supply shortages.

   The estimated WTP to avoid relatively minor ("Stage 1") water use restrictions was typically quite low and was not statistically significant (in terms of being statistically different from zero) in four of the five regions (San Francisco being the one exception, which produced a statistically significant WTP of $12.25 per household per year to avoid a future year of Stage 1 restrictions). This suggests that customers generally are willing to accept periodic imposition of low-level Stage 1 restrictions, seeing them as a periodic inconvenience rather than an event necessitating significant financial investment in supply enhancements.

3. Water reuse options, including indirect potable reuse (IPR), received a very high level of customer support.

   In each service area, survey respondents were provided an opportunity to review a list of 9 or 10 water supply enhancement options and to rank their top five preferences. In all five of the surveyed service areas, the option to expand water reuse for outdoor irrigation and industrial use was the choice most frequently selected by customers as one of the top three alternatives. Hence, expanded use of recycled water for nonpotable uses was amongst the most popular choices in each region.

   The use of recycled water to replenish local groundwaters (i.e., IPR) also was considered very favorably in all regions. It was the second most popular option in one region, and was ranked third, fourth, and fifth (out of 10 options) in the other regions.

4. Desal options were moderately supported by customers in the three regions where it was an option under consideration, and ranked above the other options that added "new" water to the local portfolio.

   Ocean desal was ranked fourth among the water supply enhancement options selected as one of the top three choices of survey respondents in San Francisco, and ranked fifth amongst the 10 options offered in Long Beach and Orlando. In each location, ocean desalting ranked behind nonpotable water reuse and the conservation options and, in all but San Francisco, ocean desalting ranked below indirect potable reuse as well. However, although recycling and conservation options were consistently ranked ahead of desal, ocean desalting did rank higher than any of the other supply-adding alternatives in the three applicable locations (e.g., adding desal was consistently preferred over importing more freshwater from outside the region, or transferring water from agriculture).

*Chapter 1*

# Introduction

## 1.1 Background

The extraction of freshwater from traditional sources such as rivers and aquifers is becoming more difficult because of tightening physical and institutional limits. At the same time, demand for clean water continues to grow. Faced with these issues, more water managers are considering water reuse and/or desalination (desal) options as part of their long-term supply plans. However, these new technologies typically are more expensive than traditional water supply sources, which makes reuse and desal difficult to justify to governing boards, customers, economic regulators, and potential funding agencies.

Although reuse and desal may appear relatively expensive, they do provide a range of important benefits not generated by most traditional supply options. Both desal and reuse offer reliable and locally controlled yields when drought, climate change, or other factors (e.g., court orders curtailing freshwater extraction) limit other options. Utility managers and others recognize that this yield reliability is likely to be highly valued by their communities. However, the absence of suitable customer valuation data makes these reliability benefits difficult to quantify in a meaningful and credible manner. This impedes the implementation of reuse and desal and poses a challenge to securing state and federal funding.

## 1.2 Objectives and Approach

This project addresses this critical gap by developing estimates of the economic value of drought-resistant water yield reliability, such as that associated with reuse and desal projects. To meet this objective, Stratus Consulting developed and implemented state-of-the-art "stated preference" surveys and statistical analyses in order to provide useful and robust estimates of household willingness to pay (WTP) for water supply reliability. In this context, values for reliability were determined based on household WTP to avoid future water use restrictions (e.g., limitations on outdoor watering). These estimates can be used by water utilities to evaluate and compare the benefits of future water supply options.

In addition to providing insight into how water utility customers value reliability, the stated preference surveys and subsequent analyses include information and data on the types of water supply options (including reuse and desal) that customers think their water utilities should pursue in the future to increase supply reliability.

The survey developed as part of this research effort was applied (with minor modifications to tailor it to local circumstances) to five water utility service areas across the United States. The five study sites included Austin, TX; Long Beach, CA; Orlando, FL; San Francisco, CA; and one other North American utility that preferred to remain anonymous (referred to throughout as "Utility X" or "City X"). The surveys were administered in the latter half of 2010 and the former half of 2011.

To ensure that all relevant issues were addressed, including the most recent advances in survey methodology and WTP analysis, and specific water-supply-related issues within each of the five utility service areas, our general methodology was as follows:

- Review the literature and knowledge on reliability measures and values
- Exchange information with participating utilities and other relevant entities to help shape the research (and surveys) so that it would be directly relevant and applicable to practical utility contexts
- Develop initial survey questions and designs using a stated preference choice set (conjoint analysis) approach to derive estimates of household WTP for supply reliability
- Conduct focus groups with customers of participating utilities and meet with participating water utilities to help design and refine the survey instrument to ensure that respondents will properly understand it
- Administer the final survey to water agency customers within the five water utility service areas (with an average of 423 completed surveys within a service area)
- Conduct statistical analyses of the survey data to generate useful and technically robust interpretations of WTP for added water supply reliability for residential customers and evaluate water supply preferences across the five service areas

## 1.3 Report Organization

The remainder of this report is organized as follows:

- Chapter 2 provides a background discussion of what supply reliability entails and describes approaches to estimating reliability values. Also included is a review of the literature on efforts to develop empirical estimates of household WTP for supply reliability.
- Chapter 3 describes the methods deployed in this research effort to develop empirical estimates of the value of water supply reliability to members of the residential sector (i.e., households served by water supply agencies). This chapter describes the development of the stated preference surveys deployed in this study.
- Chapter 4 summarizes the empirical findings derived from this research effort. Estimates of household WTP for increased supply reliability are described. In addition, the preferences expressed by the surveyed public for different water supply enhancement options are presented.
- Chapter 5 discusses the interpretation and use of the empirical information derived in this study, including key caveats. Guidance is provided on how utilities may apply or develop WTP estimates from surveys of their own customers.
- Chapter 6 provides conclusions and a suggested agenda for future research.

Appendices are also provided to offer interested readers more detailed information:

- Appendix A provides a detailed review of the empirical literature on reliability values. This supplements the more focused discussion provided in Chapter 2.
- Appendix B provides examples of the focus group materials developed and used in this study.

- Appendix C provides the survey instruments deployed in the research effort (a slightly modified version of the Internet-based survey instrument was developed for each of the surveyed service areas in order to tailor the survey to local circumstances).
- Appendices D through H provide detailed analyses of the data for each service area surveyed and empirical analyses of the data obtained.

*Chapter 2*

# Defining and Measuring Water Supply Reliability

This chapter provides a summary of the issues and literature related to valuing water supply reliability enhancement projects. First, we address key conceptual issues associated with the reliability topic, including[1]

- Defining what reliability means, including how reliability might be measured (quantified), who receives the benefits of reliability, and how reliability measures apply within the context of water supply options
- Exploring the dimensions of reliability, with a focus on the different potential sources of variability and uncertainty in water supply yields
- Articulating the difference between WTP estimates derived from this research (which focuses on the value of increasing or maintaining a target level of reliability) and water supply “portfolio theory” (which provides a basis for adjusting the cost of maintaining a given reliability target)

The second part of this chapter provides a review of the literature related to the value of water supply reliability. Given the nature of this research, we focus primarily on studies that have attempted to value WTP for improved reliability [or willingness to accept (WTA) a decrease in the level of reliability], using stated preference techniques.

## 2.1 Defining Reliability

The goal of any water supplier is to deliver a reliable water supply. The term “reliability,” as used here, refers to the ability of a water supply option to produce a given yield (e.g., in million gallons per day, acre-feet per year) on a reasonably stable, continuous basis, whenever the utility wishes to tap and operate that given source. In other words, a reliable water supply option is one that produces a predictable and reasonably stable target yield, without much variability in or uncertainty about how much water will be produced over a given time interval. The following sections provide further insight into the different types and dimensions of reliability.

### 2.1.1 Types of Reliability

One complication in describing or monetizing the benefits of enhanced water supply reliability is that the term “reliability” can apply to a wide range of circumstances or sources

[1]This material is based in large measure on related prior work prepared for the Awwa Research Foundation (now named the Water Research Foundation, WaterRF) (Raucher et al., 2005), the WateReuse Research Foundation (or the Foundation), and the Federal Bureau of Reclamation (Kasower et al., 2007).

of uncertainty in supply. For our purposes, there are three general types of reliability enhancement contexts that apply to regional water supply projects:

- *Periodic adverse events, such as droughts* (moderate-probability, moderate-consequence risk). Droughts are fairly common events, occurring periodically over a span of several decades. The frequency and severity of droughts may vary considerably over time and across locations, but most water customers (e.g., residential users) have some direct experience with periodic drought years and their associated impacts, such as the imposition of water use restrictions. As described in subsequent sections, there is a reasonable amount of published research on household WTP to avoid drought-related water use restrictions.
- *Episodic, catastrophic events, such as earthquakes* (low-probability, high-consequence risk). Water supply reliability also can be enhanced in the context of what might happen in the aftermath of a somewhat extreme event such as a major earthquake, flood, levee failure, or terrorist attack. This kind of reliability issue—which may also be labeled "resiliency"—can be especially pertinent when a community relies predominantly on a water supply imported from a distant source. In an import-reliant community, if and when an extreme event such as an earthquake occurs, local water projects may be able to provide some level of water service if the usual imported supplies are cut off, perhaps for extended periods of time. In such cases, the value of reliability to the region's residents would be extremely high because the local supply would be meeting the most highly valued, essential human needs. However, monetizing such values is challenging empirically, given that existing research has focused on the lower-consequence but more frequent event of periodic drought, rather than the value of water in a large-scale, long-lasting emergency situation.
- *Quasi-routine inconvenient events, such as infrastructure repair* (moderate-probability, low-consequence risk). The infrastructure conveying water to customers, such as finished water transmission mains between a water treatment plant and the customer, are another source of reliability risk. Water main breaks create unscheduled disruptions in service to some customers, and even scheduled efforts to replace or rehabilitate distribution lines may result in some temporary disruption of water service. Most water users periodically experience these events, and impacts are typically limited to temporary inconveniences associated with having no water on tap for several hours (or perhaps up to a few days) and street and parking disruptions because of flooding or water main repair work. There is some evidence that households have a positive WTP for less frequent, shorter-duration events and, in particular, value efforts to have scheduled events (e.g., announced, planned repairs) rather than unscheduled events (e.g., an emergency response to a main break) (Damodaran et al., 2004, 2005).

The previous discussion describes a broad range of contexts in which residential water supply reliability issues arise. Table 2.1 provides a listing of specific factors that can affect residential water supply reliability (including some of the topics previously mentioned).

For the purposes of this research, we focus on reliability within the context of long-term supply planning. This primarily includes planning for periodic (drought) events through the development of new supply sources. Our research does not focus on the aspects of reliability related to technological (e.g., water quality, technology performance, availability of power) or delivery infrastructure issues (e.g., service interruptions).

**Table 2.1. Dimensions of Reliability in Water Supply**

| |
|---|
| The dimensions of reliability (i.e., the factors that can impact the reliability of obtaining targeted yields) include<br>1. Weather and climate—such as periodic drought cycles, as well as longer-term potential changes in climatic regimes (e.g., those that reduce snow pack or longer-term precipitation patterns)<br>2. Emergency events—such as seismic or terrorist activities that may disrupt the availability or access to traditional water sources (e.g., damage to conveyance systems needed to import distant waters to local water supply agencies)<br>3. Nonlocal political and institutional factors—such as the activities or policies of state, federal, or other entities outside of the immediate community that can create uncertainty about how much nonlocal (i.e., imported) water can be acquired by and delivered to the local utility<br>4. Energy availability and cost—such as issues related to power grid capacity and the price volatility for power that may inhibit the reliability and escalate the cost of energy-intensive treatment techniques and long-distance water conveyance systems<br>5. Technology performance—such as the actual field performance of full-scale pretreatment, membranes, beach wells, and/or other components of desal or reuse that remain somewhat novel or highly influenced by site-specific (e.g., water quality) conditions, making long-term yield reliability hard to predict<br>6. Water quality—such as how influent water quality and/or the result of post-desal or recycled water blending affect the cost or usability of product water (e.g., failure to meet drinking water standards)<br>7. Delivery infrastructure—such as how distribution system conditions may preclude reliable delivery of product water to customers |

### 2.1.2 How Water Projects May Provide Benefits by Improving Reliability

Water supply projects can improve reliability in different ways, depending on the type of water supply and local circumstances. The extent to which a water supply project enhances reliability depends on site- and project-specific circumstances. However, a few general observations often apply to various classes or types of water supply enhancement projects, including the following:

- *Projects that generate local water*, especially in regions that rely exclusively or predominantly on imported supplies, are likely to provide reliability benefits for periodic risks such as droughts, as well as infrequent but catastrophic events such as earthquakes. Drought protection may arise because the additional local supplies diversify the water supply portfolio (e.g., the drought impacts may be more severe for the imported source than for the newly developed local source), and because the added local source provides additional total capacity. The impacts of catastrophic risks are likely to be reduced because when the imported supply is cut off or severely curtailed by a seismic or other event, the local source remains available (and may be the only water available for local basic needs).
- *Projects that enable importation of water*, especially in regions that rely exclusively or predominantly on local supplies, also provide reliability benefits for both periodic drought and potential catastrophic events. As in the case previously discussed—which is the other side of the same coin—the diversification and overall expansion of the water supply portfolio provide value in several circumstances.

- *Projects that include reclamation or desal*, or otherwise make productive use of waters previously considered unsuitable for use (e.g., by using advanced treatments to render low-quality waters potable or fit for irrigation use), also tend to provide reliability benefits for both drought and catastrophic events. This is true regardless of whether other water sources tapped in the area are local or imported. Drought protection arises because the new sources are not drought-sensitive and thus their yields have low or zero covariance with yields from traditional water supplies (see the following portfolio theory discussion). In addition, because desal and reuse projects provide added capacity and may be developed as local (or regional) sources, they provide reliability benefits in the event of catastrophic events that might curtail delivery of nonlocal water.
- *Projects that replace or upgrade treatment or distribution infrastructure* tend to generate reliability value by reducing the risk of unscheduled short-term service disruptions. They also may provide some drought protection insofar as infrastructure renewal probably reduces the volume of water lost to leaks, thereby enabling more end use from the existing supplies (in effect, increasing overall system capacity in terms of delivered water).
- *Projects that add water storage* also provide a buffer against seasonal or interannual fluctuations in the available yields from traditional water supply sources. For example, aquifer storage and retrieval (ASR) programs can make use of excess water in wet periods and store that water for use in dry periods. These and other relatively large-scale (i.e., more than a day or two of supply) projects increase reliability during periodic drought events and also can help improve intra-annual reliability by enabling more water availability in dry months (which also tend to be periods of high water demand).

### 2.1.3 Who Receives Reliability Benefits?

Another important aspect of reliability is the consideration of who receives the benefits (e.g., fewer water use restrictions) and who pays any cost premiums associated with providing added water supply options. These distributional aspects can be viewed across types of water users (e.g., customer class) and also across income or other demographic characteristics within a service area.

In terms of customer classes or types of water users, reliability benefits can accrue to

- *Residential customers* who may be affected by periodic impacts on lawn and garden irrigation and other possible water use restrictions in drought periods. Residential customers benefit from additional overall supply reliability in dry periods.
- *Recreational users* who benefit from sports fields and parkland areas irrigated with reclaimed water or whose outdoor irrigation of such facilities in dry periods is enabled by the availability of additional supplies for other applications.
- *Commercial, industrial, and institutional (CII) customers* for whom reliable water service (quality and quantity) can have significant financial and other business impacts, including overall community economic vitality.
- *Agricultural and other potential large-scale water users* for whom water is a key input into production and income.

Throughout this report, our research is focused on reliability value within the context of residential water users and recreational users of irrigated green spaces. An important point regarding these customers is that, in some cases, they may not be directly receiving the water supplies made available through reliability-enhancement projects (this may be the case with desalinated or recycled water projects). However, if they are located in communities or regions where additional supplies are made available to other customers, then they will still benefit—albeit indirectly—from the increased overall supply and drought resistance of the broader community portfolio.

## 2.2 Valuing Reliability of Water Supply

Utility managers and others recognize that maintaining or improving the reliability of their water supply yield is likely to be highly valued by their communities. However, the absence of suitable customer valuation data makes these reliability benefits difficult to quantify in a meaningful and credible manner. This impedes decision making for long-term water supply investments because these investments are increasingly expensive. Thus, utility managers (and their governing boards) typically desire credible information to assess whether the value (benefit) of water supply reliability investments are high enough for their customers to warrant the potential rate increases needed to pay for them.

Two distinct methods can be used to investigate the value of reliability:

1. The portfolio theory approach, as developed initially for managing financial assets, provides a framework for comparing water supply options using a reliability-based cost adjustment for attaining a given reliability target.
2. The WTP approach (the focus of this research) uses economic valuation techniques to directly estimate the values (i.e., WTP) for reliability held by water utility customers.

The following sections briefly describe each approach, highlighting the differences between portfolio theory and WTP estimates (such as derived from this research), as applied to water supply reliability.

### 2.2.1 Portfolio Theory

Portfolio theory offers water supply managers a sound conceptual basis and statistical approach for revealing the added value that can be attributed to reliability enhancement projects. The portfolio approach is used to adjust the costs of alternative water supply options to account for differences in reliability relative to a given reliability target for the portfolio (e.g., to deliver a given targeted quantity of water with 95% confidence, year to year).

Originally developed for application in financial markets, portfolio theory provides some useful insights into how water supply planners might develop and manage the portfolios of water sources available to them. The central premise, long recognized and applied by financial managers, is to jointly maximize expected returns (water yields) and concurrently also reduce the overall variance (fluctuations in yields across years or seasons) in portfolio returns. This can be accomplished by minimizing the covariance in yield risks across the assets held in a portfolio (Markowitz, 1952).

In essence, portfolio theory is a statistics-based formalized embodiment of the old maxim about not placing all of one's eggs in one basket. The basic premise of portfolio theory applies to water resources planning. Each water supply option can be viewed as an asset that is subject to some sources and degree of risk (where risk refers to variability or uncertainty in water yield, cost, or both). There may well be a premium value that a risk-averse community would be willing to pay to better manage its water risks, by providing some insurance and/or by providing some variance-balancing water portfolio diversification. The portfolio approach, as applied to water supply planning, introduces the unique risk/benefit profiles of different water supplies into the analysis, thus allowing an assessment of increased (or at least equal-to-existing) supply reliability at the least cost, rather than merely the least-cost total supply irrespective of reliability and community values.

As with financial assets, sources and levels of risk vary across different types of water assets:

- For many traditional surface water sources, a key source of yield risk is the weather and its impact on local hydrologic conditions (e.g., droughts that leave stream flows or reservoirs too low to support desired levels of water extraction).
- Cost risks (or, more suitably, net revenue risks) may be associated with increased pumping and treatment costs, which may arise with declining aquifer levels, deteriorating raw water quality, added regulatory requirements, and other factors. Net revenue risks also can be linked to declines in revenue collections (as when drought restrictions curtail water use and sales, and revenues decline below total annualized costs because volume-based water pricing rates remain fixed—a problem that may be addressed where rate structures help maintain revenue neutrality).
- Other sources of risk for traditional surface and groundwater sources include contamination (e.g., pollutant spills), overextraction by other users (e.g., externalities arising where water is a common property resource), and new institutional constraints (e.g., minimum in-stream flow requirements to account for ecosystem needs or regulatory limits on groundwater extraction to prevent subsidence).

A more in-depth discussion of portfolio theory is provided in Kasower et al. (2007) and Wolff (2007). These papers also offer simple empirical illustrations of how much added value (in terms of reducing the cost of attaining a target level of reliability) may be derived from having a water supply with a yield variability that is uncorrelated (or negatively correlated) with the variability of other source water options in the community's water supply portfolio. This can be used to develop a "constant reliability-adjusted cost" per unit of water delivered, which can then be used to develop a reliability-adjusted cost-effectiveness comparison of water supply options.

### 2.2.2 Willingness-to-Pay Approach

Portfolio theory offers water supply managers a sound conceptual basis and a statistical approach for revealing the added value (cost savings) of reliability enhancement projects. However, the portfolio approach does not provide a direct empirical examination of how much "value" people place on added reliability (e.g., the WTP to have a higher level of reliability for the community supply, such as increasing the probability of meeting a target total portfolio yield from 95% to 99%).

Estimating WTP for changes in the reliability of water supply involves analytic techniques to elicit the values people place on reliability. Estimation procedures used to value changes in reliability for residential water users are generally based on one of two different primary research approaches:

- *Stated preference* methods determine estimates for reliability based on the analysis of household responses to hypothetical choices posed in surveys
- *Revealed preference* methods infer the value of reliability from data obtained from choices and decisions made in the marketplace (e.g., expenditures made to obtain higher levels of reliability or to avert potential shortages sometimes can be used to infer the value of reliability, but are generally more applicable when derived from customer choices rather than utility-level decisions, which may be driven by a suite of institutional factors)

Another estimation method is known as *benefits transfer* (BT). BT is considered a secondary valuation method because it relies on applying the empirical results derived from primary research, rather than deriving empirical results directly. BT is discussed in greater detail later (Chapter 5).

One other method of quantifying the value of reliability attempts to infer values from available cost and price data. Although “cost” does not necessarily equate to “value,” the cost that a city incurs for increased storage to improve reliability can be used—with suitable caveats—as a rough proxy for the value of a reliable water supply. This is especially true when water demand is inelastic (i.e., for necessities), and least-cost supply alternatives are used as proxies for value. Additionally, avoided costs due to higher levels of reliability sometimes can be used to infer the value of reliability.

In recent years, economic and mathematical modeling techniques have also been developed to derive WTP estimates based on available data. These models have been used to estimate household WTP for changes in a combination of probabilistic water supply reliability and the retail price of water (see Lund, 1995; Jenkins and Lund, 2000; Alcubilla and Lund, 2006). Advantages of these models are their ability to examine a complete shortage probability distribution (not just specified events) and their ability to account for price effects (i.e., where higher water rates increase incentives for conservation and reduce the impact of shortages). Although this conceptual approach could provide useful insights into WTP to avoid a range of shortages, it has only been used to evaluate hypothetical scenarios and has not been applied based on real-world data.

## 2.3 Review of Existing Literature

The following sections overview stated preference, revealed preference, and cost-based studies related to how residential water users value the reliability of their water supply (i.e., WTP).[2] Given the nature of our research (using stated preference techniques to elicit WTP for improved reliability), we focus primarily on stated preference studies that examine the value of water supply reliability to residential customers.

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[2]The numbers reported here have been adjusted based on the Consumer Price Index (CPI) to reflect mid-2011 U.S.$ values.

### 2.3.1 Stated Preference Studies

Stated preference methods rely on survey questions that ask individuals to make a choice, describe a behavior, or state directly what they would be willing to pay for specified changes in reliability. The most widely used stated preference technique has been the contingent valuation method, where respondents are presented with information about water supply reliability and relationships between water supply reliability and usability of the resource. Respondents are then asked to state or indicate to the researcher how much a given change in water supply reliability would be worth to them.

More recently, choice experiments, an alternative stated preference approach, have begun to be used more extensively to estimate WTP. Choice experiments—long used in marketing studies—are a survey-based technique in which consumers are presented with two or more options for a good or service and are asked to state which options they prefer. By examining consumer preferences for the attributes and prices associated with the preferred option, WTP is inferred.

Values for reliability are typically defined in stated preference studies as WTP to avoid a particular shortfall event. Water-supply shortfall events are defined in different ways across studies. Factors used to describe a shortfall event include the percentage of water available compared to the amount fully demanded (the shortfall amount), the frequency with which this condition may occur (e.g., 1 in 10 years), and the probability of a single event. In other studies, respondents are questioned on their WTP to reduce the probability of an event, not avoid it. A few more recent studies have elicited WTP to avoid impacts associated with shortages (e.g., watering restrictions).

The following briefly summarizes stated preference studies that have attempted to value water supply reliability using both contingent valuation and choice experiment techniques (more detailed information on each study is provided in Appendix A).

#### *2.3.1.1 Contingent Valuation Studies*

In 1987, Carson and Mitchell conducted the first formal stated preference study related to water supply reliability. This study, conducted for the Metropolitan Water District of Southern California (MWD), used contingent valuation method techniques to determine the economic value that residents in southern and northern CA place on changes in water supply reliability. The authors used a discrete choice referendum survey format to estimate household WTP to avoid water shortages of a given magnitude and frequency. Specifically, respondents were asked whether they would vote yes or no on a referendum that would alleviate the threat of a specific water shortage scenario, given a specified (annual) cost to their household if the referendum were to pass. Median annual household WTP was determined for four reduction scenarios, based on a magnitude of reduction ranging from 10% to 35%.

In 1993, the California Urban Water Agencies (CUWA) hired Barakat and Chamberlin, Inc. to conduct a second stated preference study related to reliability.[3] The objective of this study

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[3]This study was republished by its authors in a peer-reviewed journal in 2001 (Koss and Khawaja, 2001).

was to measure WTP among water users in 10 CA water districts. More specifically, they sought to estimate how much residents are willing to pay to avoid water shortages of varying magnitude and frequency. Shortage magnitudes ranged from 10% to 50% and frequencies ranged from once every 3 years to once every 30 years. The authors used a referendum-style, double-bounded dichotomous choice survey to estimate household WTP.

In 1994, Howe and Smith used contingent valuation to measure customers' WTP for improved reliability (and WTA for *reduced* reliability) in three Colorado towns: Boulder, Aurora, and Longmont. For this study, respondents were asked to consider hypothetical changes in their city's level of reliability (increases and decreases in frequency of a specific shortage event) and to assert whether or not these changes would be acceptable if accompanied by appropriate (but unspecified) changes in their water bills. The type of water shortage investigated in the study was defined by the authors as a "standard annual shortage event" (SASE): a "drought of sufficient severity and duration that residential outdoor water use would be restricted to 3 hours every third day for the months of July, August, and September" (Howe and Smith, 1994).

Griffin and Mjelde (2000) used stated preference techniques to value water supply reliability among households in seven Texas cities. The primary objective of this study was to investigate the value of current water-supply shortfalls (existing shortages of known strength and duration). The authors also attempted to determine the value of future shortfalls (probabilistic shortages of differing strength, duration, and frequency). The survey used in the study included two contingent valuation questions: a closed-ended WTP question that described a current supply shortfall of *X*% of the community's water demand for a duration of *Y* summer days and an open-ended WTP or WTA question concerning a hypothetical increase or decrease in future water reliability.

#### *2.3.1.2 Choice Experiment Studies*

Two recent studies conducted in Australia (Hensher et al., 2006; Tapsuwan et al., 2007) used choice experiment survey formats to examine household preferences for water supply reliability in terms of WTP to avoid drought restrictions. In the surveys, consumers were presented with various options for goods or service levels (with different attributes) and asked to state which options they preferred. Because price is included as one of the attributes, WTP for a specific attribute is indirectly recovered from people's choices (Hanley et al., 2001 as cited in Tapsuwan et al., 2007).

Tapsuwan et al. (2007) used a choice experiment survey to estimate household WTP in Perth, Australia, for different source development options and for avoidance of outdoor water restrictions. To measure consumer preferences, the authors developed a choice experiment survey that included program options with different attributes such as measures of regular outdoor restrictions (e.g., number of days per week households are allowed to water their landscapes), probability and severity (duration) of a complete sprinkler ban, sources of alternative water supplies, and cost to the household (as an increase in annual household water bill). Overall, the study found it difficult to identify preferences to pay for reduced risk of water restrictions in either the short or long term. The authors conclude that respondents may have found the attributes presented in the choice set format too difficult to understand, particularly because it involved an assessment of the risk of an event that may have been difficult to grasp. Alternatively, the source development options included as attributes may have introduced a labeling bias in the questionnaire. If source development was seen as an overriding factor and respondents ignored associated levels of reliability presented in each choice set, some modifications to the survey instrument would be required in the future in order to assess the value of reliability.

Hensher et al. (2006) used a choice experiment to evaluate consumer preferences for avoiding drought restrictions in Canberra, Australia. For this study, the authors presented respondents with a series of six choice experiments covering restrictions on the use of water. Each experiment described two restriction scenarios, and respondents were asked which of the two options they preferred. Based on modeling of respondents' choices between the two options in each experiment, the authors found customers were not willing to pay to avoid most types of drought-induced restrictions. To estimate WTP, the variables included in the model were differentiated into two variables based on the findings previously discussed: "frequency of restrictions that matter," defined as those that apply every day, last all year, and are stage 3 or higher; and "frequency of restrictions that don't matter," which are all other restrictions. The "restrictions that don't matter" include those types of restrictions found to be nonsignificant in the economic model developed based on survey results.

#### *2.3.1.3 Summary of Stated Preference Studies*

Table 2.2 provides a summary of annual WTP for reliability improvements based on the studies previously reviewed. With the exception of households in Canberra, Australia (Hensher et al., 2006), it appears that most households are willing to pay in excess of $100 annually for reliability improvements.

Overall, although the stated preference studies previously discussed are valuable in terms of gaining insight into the value of reliability, none of them are perfect in their methodology. In addition, it is somewhat difficult to interpret how to apply the results of these studies to value reliability in the context of 2011. The survey methods used in most of these studies to develop the data, as well as the statistical approaches used to analyze these data, have improved over the years because most of these studies were implemented.

Although stated preference approaches have been applied to the valuation of nonmarket goods for many years, the method has limitations that need to be acknowledged and considered. For example, Griffen and Mjelde (2000) note that one difficulty with stated preference studies for water reliability is the notion of the "birthright" perspective. It is not uncommon for respondents to view water as an inalienable right. Consequently, although respondents value water reliability highly, the notion that water should be free can lead to a reduction in their stated WTP for reliability. However, if the limitations are acknowledged and efforts are made to perform the studies in an appropriate manner, stated preference studies can yield informative results.

Finally, in addition to the studies previously reviewed, a handful of stated preference studies have also been conducted in relation to WTP to avoid temporary disruption in supply (lasting a few hours to a couple of days) due to infrastructure failure and/or repair (see MacDonald et al., 2003; Damodaran et al., 2004; Hensher et al., 2005; Brozovi´c et al., 2007). These studies are more related to the reliability of infrastructure than to the overall reliability of supply and are therefore not emphasized here.

**Table 2.2. Summary of Results from Stated Preference Studies**

| Source | Shortfall Amount | Frequency | Probability | Annual WTP/ Household (mid-2011 U.S.$)[a] |
|---|---|---|---|---|
| Carson and Mitchell (1987) | 10% to 15% | 1 in 5 years | 20% | $165 |
| Carson and Mitchell (1987) | 10% to 15% | 2 in 5 years | 10% | $305 |
| CUWA (1994) | 20% | 1 in 30 years | 3.3% | $176 |
| Carson and Mitchell (1987) | 30% to 35% | 1 in 5 years | 20% | $228 |
| Carson and Mitchell (1987) | 30% to 35% | 2 in 5 years | 10% | $517 |
| CUWA (1994) | 50% | 1 in 10 years | 5% | $311 |
| Griffin and Mjelde (2000) | na | na | na | $134 |
| Griffin and Mjelde (2000) | na | na | na | $154 |
| Howe and Smith (1994)[b] | 0.16% to 9.2%[c] | na | na | $98[d] |
| Howe and Smith (1994) | 0.23% to 12.2%[e] | na | na | $113[f] |
| Hensher et al. (2006) | na | na | na | $243[g] |
| Tapsuwan et al. (2007) | na | na | na | $57[h] |

na = not applicable.

[a]The numbers reported here have been adjusted based on the CPI to reflect mid-2011 US$ values.

[b]Howe and Smith (1994) also estimated WTA values for decreases in reliability. Annual WTA results per household for approximately a 0.7% to 11% decrease in reliability, depending on the city, ranged from $80 to $195. Annual WTA results for approximately a 1.7% to 40% decrease in reliability, depending on the city, ranged from $95 to $281.

[c]This percentage range does not represent the magnitude of the shortfall, as is the case in the other studies. This range represents increased probability over the base probabilities of the SASE. The actual percentage increase is dependent on the city. The associated dollar values are the annual WTP per respondent for an increase in current reliability. If "no" respondents for this increased probability range are included in the dataset (respondents' WTP = $0), the WTP range is from $19 to $33 per year per respondent.

[d]Value represents the average of the WTP range given in the study ($82 to $106 per year).

[e]See table note c. If "no" respondents for this increased probability range are included in the dataset, the WTP range is from $15 to $29 per year per respondent.

[f]Value represents the average of the WTP range given in the study ($75 to $140 per year).

[g]This is the average amount that householders are willing to pay to move from a situation with continuous restrictions at stage 3 or above all year every year to a situation with virtually no chance of restrictions.

[h]This is the annual amount householders are willing to pay for the option of moving from one day to three days of allowable sprinkler use.

### 2.3.2 Revealed Preference and Cost-Based Studies

A few studies have used the revealed preference and cost-based methods to determine values for water supply reliability. Fisher et al. (1995) explored how price can be used as a tool to reduce demand during a drought. Using a range of estimated price elasticities for residential customers (from selected studies), the authors calculated the loss of consumer surplus associated with a price-induced 25% reduction in consumption in the East Bay Municipal Utility District (CA) service area. With varying demand elasticities, welfare losses were estimated within a range from $63 to $283 per acre-foot (updated to 2011 U.S.$). This loss in consumer surplus is equated to WTP for improved reliability.

In 2002, the California Recycled Water Task Force was established to investigate specific recycled water issues. The economic group of the task force was charged with identifying economic impediments to enhance water recycling statewide. The resulting report uses a case study of the Groundwater Replenishment System (GWRS) in Orange County as an illustration for the importance of economic feasibility analysis. The GWRS was designed to recycle an estimated 70,000 acre-feet per year of effluent and inject it into the Orange County Aquifer. According to the Groundwater Replenishment System Financial Study (Public Resources Advisory Group, 2001), the value of droughtproofing (the value of reliability), based on drought penalties and rate increases for consumers ranged from $220 to $314 per acre-foot per year ($9.5 to $16.3 million per year for 40 years, with a total present value of $285 million with a 5.5% discount rate, updated to 2011 U.S.$) (Recycled Water Task Force, 2002).

In a similar investigation in 1997, the National Research Council (NRC) estimated that if Orange County were to lose its reliable groundwater supply to saltwater intrusion, the cost of securing water by retail producers would jump from the 1997 cost of $106 million to $210 million. The $104 million increase arises because the water once pumped from the aquifer would now have to be purchased from MWD at the uninterruptible rate (NRC, 1997). The sharp increase in price charged by MWD for uninterruptible water supplies highlights the fact that reliability has a key role in water pricing (Paul, 2004) (i.e., as actual or potential shortages worsen and demand outpaces supply, users are willing to pay more for water).

Varga (1991) investigated the role of local projects and programs in the city of San Diego in enhancing imported water supply and improving reliability. MWD provides water to San Diego from the Colorado River and northern California, based on availability. To encourage the use of existing local reservoir capacity and improve the reliability and yield of the imported water system, MWD and California introduced water rate credits for serviced cities. The first program instituted was the Interruptible Credit program. An interruptible credit applies to water that either could be reduced or could have its delivery interrupted by MWD or another external agency. In 1991, the interruptible credit rate was approximately $73 per acre-foot (2011 U.S.$). The second program is the Seasonal Storage Credit program. This program encourages water agencies to use available local storage to increase the capacity and yield of the imported water system. The 1991 seasonal storage rate was approximately $136 per acre-foot (2011 U.S.$). MWD is paying for direct increases in reliability, and therefore, the credit rates can be used as the value for an acre-foot increase in water supply reliability.

Thomas and Rodrigo (1996) measured the benefits of nontraditional water resource investments. The focus of the study was again on MWD and its member agencies. They investigated the benefits of developing additional resources in the region through several alternatives including increased imported supplies (base case), conjunctive storage of local groundwater basins, and recycled water and groundwater recovery projects (preferred case). To determine the value of the preferred case, the savings attributable to each of these resources were compared with the yield associated with the resource. Thomas and Rodrigo note that “dividing the total present value of benefits by the expected groundwater replenishment deliveries (e.g., the difference between the base case and the preferred case and the groundwater case for conjunctive use storage), yields a dollar/AF index” (Thomas and Rodrigo, 1996). In the case of conjunctive use storage, the modeling revealed that carryover or drought storage, which helps ensure greater reliability during dry periods, provides a benefit of approximately $433 per acre-foot (2011 U.S.$) to the region.

In 2003, Wade and Roach investigated the reduction in National Economic Development (NED) Benefits if water supplies to Metro Atlanta were capped at year 2000 water withdrawal levels and no new supply alternatives existed. This analysis estimated shortage costs including costs of shortage management (conservation and reclamation); agency revenues lost from reduced water sales; lost consumer surplus; and economic losses to the region. The water and wastewater NED Benefits were summed to determine total shortage losses through 2050 (present value at year 2000 using a federal discount rate of 6.625%). The present value NED Benefits loss associated with a cap on supplies was estimated to be more than $25.0 billion (2011 U.S.$). Total losses at 10-year intervals were converted to costs per acre-foot based on the total shortage amounts. Water and wastewater losses were found to range from $4090 per acre-foot (2011 U.S.$) for a 17% shortage to $28,650 per acre-foot (2011 U.S$) for a 47% shortage, over the 40-year period from 2010 to 2050.

An overview of the value of reliability inferred from results of revealed preference and cost-based approaches is provided in Table 2.3. When compared on a dollar per acre-foot basis, these estimates are considerably lower than those based on WTP from the stated preference studies previously highlighted. This reflects the fact that stated preference results are designed to reflect the real value (i.e., WTP) of water supply reliability to customers (e.g., households), whereas cost-differential-based results are simply reflective of agency pricing or expenditure decisions that are not likely to reflect value (WTP) considerations. In other words, stated preference studies—if suitably designed and implemented—provide a more relevant and better measure of household WTP for reliability than the available suite of revealed preference studies.

## 2.4 Conclusions

Although there is a reasonably large body of past empirical research on the value of enhanced water supply reliability to households, many of the underlying data are quite outdated (i.e., originating in the 1980s and 1990s). In addition, the framing of the valuation scenarios (often implying elimination of uncertainty and, in essence, guaranteeing no future shortages) and the valuation approach used in the older contingent valuation method studies make it difficult to interpret the results of prior studies within the practical context of water utility planning in 2011 and beyond (although a discussion of their possible interpretation is offered in Chapter 5).

Based on the limitations revealed by the literature review, there is considerable merit in developing current empirical estimates of WTP for water supply reliability to reflect current period economic and social realities. A more current investigation also enables us to deploy more advanced survey design (using choice experiments) and data analysis methods. The next chapters describe the development of the new empirical research and our findings.

**Table 2.3. Water Supply Reliability Values Inferred from Revealed Preference or Cost and Price Differential Results**

| Source | Value (mid-2011 U.S.$ per acre-foot)[a] | Basis |
|---|---|---|
| Fisher et al. (1995) | \$63 to \$283 | Welfare loss per acre-foot due to a price-induced reduction in water consumption of 25% |
| Recycled Water Task Force (2002) | \$220 to \$314 | The value (acre-foot per year) of droughtproofing based on drought penalties and rate increases for the customer |
| NRC (1997) | \$406 | The difference in cost of local groundwater supplies versus the MWD uninterruptible rate |
| Varga (1991) | \$73 | The rate per acre-foot that MWD credits local water retailers to store imported water in local reservoir to increase reliability of imported supplies |
| Varga (1991) | \$136 | The rate per acre-foot that MWD credits local water retailers to seasonally store imported water to increase capacity and yield of the imported water system |
| Thomas and Rodrigo (1996) | \$433 | The benefit per acre-foot of conjunctive use storage to ensure greater reliability |
| Wade and Roach (2003) | \$4090 to \$28,650[b] | Total present value losses associated with a 17% and 47% (cumulative through 2050) reduction in supply in metropolitan Atlanta |

[a]The numbers reported here have been adjusted based on the CPI to reflect mid-2011 US$ values.

[b]Present value over 40 years. In terms of annual values, this is equivalent to \$294 to \$2056 per acre-foot per year.

*Chapter 3*

# Methods and Data

To meet our research objectives, the project team developed and implemented a series of choice experiment stated preference surveys of residential customers within five U.S. water utility service areas: Austin Water (TX), Long Beach Water Department (LBWD, southern CA), Orlando Utilities Commission (OUC, FL), San Francisco Public Utilities Commission (SFPUC, northern CA), and one other, anonymous North American utility. This chapter provides a detailed description of the survey methodology, implementation, and analysis, as follows:

- Overview of choice experiment form of stated preference
- Development of initial survey design
- Implementation of focus groups, including key insights and findings
- Development of final survey instrument and pretest
- Survey implementation and sampling methods
- Model and data analysis

## 3.1 Choice Experiment Form of Stated Preference

Stated preference methods rely on survey questions that ask individuals to make a choice, describe a behavior, or state directly what they would be willing to pay for specified changes in the availability or quality of a resource (e.g., water for household use). For this analysis, the project team used a stated choice, or choice experiment, version of the stated preference method to elicit utility customer WTP for improved water supply reliability.

Choice experiments are a survey-based technique in which a consumer is presented with two or more options for a good or service and asked to state which option he or she prefers. Each option typically is described by a series of attributes such as price, quality, and/or quantity. For example, in the survey deployed in this study, respondents were asked to choose between future water supply reliability scenarios with the following attributes: (1) number of avoided water use restrictions over the next 20 years (with two severity levels for the potential water use restrictions, as described in greater detail later) and (2) the cost to the household (stated in terms of the change in monthly and annual household water bills) associated with ensuring the given level of water supply reliability. By examining consumer preferences for the attributes and prices associated with their preferred option, WTP is inferred by the researcher using statistical analysis.

The following sections overview the different forms of stated preference evaluations, including contingent valuation and stated choice methods. This discussion helps to describe our rationale for the use of the stated choice method.

### 3.1.1 Alternative Stated Preference Approaches: Contingent Valuation

The earliest and most widely applied stated preference method is contingent valuation. A typical contingent valuation survey asks respondents about their values for one proposed action compared to the status quo. For example, a conventional contingent valuation exercise in the current context might have asked respondents about their values for reducing the imposition of water use restrictions from 2 years out of the next 10 to 1 year out of the next 10.

The contingent valuation approach was applied in most of the stated preference studies reviewed in Chapter 2. Indeed, contingent valuation was the approach deployed in all the cited studies from the late 1980s through 2000. Only the more recent, Australian-based efforts (Hensher et al., 2006; Tapsuwan et al., 2007) use the stated choice approach. The reliance on contingent valuation is one reason often cited that there is some skepticism about the validity of the empirical results from the earlier studies. For example, some reviewers have pointed out that the level of "mental math" required by respondents in the Carson and Mitchell (1987) survey—coupling severity of the impact (in terms of percentage reductions in water availability) with the probability associated with different potential frequencies of shortages—may explain why respondents did not appear to provide internally consistent responses in terms of their stated WTP.

Although contingent valuation has its limitations and critics, more than 6000 studies involving contingent valuation have been published in the United States and other countries since 1963, including many in the peer-reviewed literature. Contingent valuation—and other stated preference methods—are still evolving and hence continue to generate scientific discussion and research. Nevertheless, enough has been learned to gain wide acceptance of contingent valuation. It is commonly applied by a number of federal agencies. In fact, the Office of Management and Budget (OMB) and the U.S. Environmental Protection Agency (EPA) have published guidelines for its application in policy analyses. The National Oceanic and Atmospheric Administration (NOAA) and the U.S. Department of the Interior (DOI) have approved contingent valuation for natural resource damage assessments involving releases of oil and toxics into the environment.

In the consideration of contingent valuation for the current study, some limitations became apparent. Our goal was to evaluate a range of alternatives, representing a mix of changes in both the probability of future water shortage events (i.e., the number of years out of the next 20 in which restrictions would be required) and the severity of the associated water use restrictions put in place (i.e., whether a Stage 1 or a more severe Stage 2 set of restrictions would be imposed). Valuing more than one proposal in the same contingent valuation survey has significant potential pitfalls. Conducting separate contingent valuation studies, each focused on one of the alternatives, also has some undesirable features.

### 3.1.2 Alternative Stated Preference Approaches: Attribute-Based, Stated Choice

To address these issues, we looked to the other main branch of stated preference methods, the so-called attribute-based methods (ABMs), also referred to as stated choice questions. In ABM surveys, respondents are presented with two or more alternatives. Each alternative is described in terms of its features or "attributes." Dollar values are included by making one of the attributes the cost of each alternative to the respondent. Several alternatives can be introduced by varying the attributes. Respondents are asked either to choose their most preferred alternative or to rank the alternatives.

The general valuation method we applied to the study involves the use of stated choice questions (also known as "conjoint questions"). Holmes and Adamowicz (2003) and Kanninen (2007) provide overviews of stated choice methods and include citations to most of the literature on the topic. Stated choice questions in this context are used to present individuals with a tradeoff between differing levels of goods or services (e.g., frequencies and severities of potential future water use restrictions) and other attributes including cost. Choices are then used to infer economic values.

The research team considered the relative advantages of contingent valuation and stated choice approaches. A contingent valuation method has the virtues of directness and simplicity. In a typical contingent valuation study, respondents are asked about their values for a single program. Our goal, however, was to value various alternatives to the status quo, so we could discern whether (and how much) it might matter to differentiate the more severe water use restrictions (Stage 2) from the less severe versions (Stage 1). Valuing all options in a single survey using traditional contingent valuation methods would have been challenging. Numerous standalone contingent valuation questions would have been required, and splitting the sample and conducting separate contingent valuation surveys would have increased overall sampling costs or reduced the sample size per question to very small numbers. In contrast, ABMs are capable of valuing more than one program in the same survey, and we turned in that direction to incorporate these issues.

Stated choice questions for ABMs involve presenting survey respondents with two or more alternatives. Each alternative is described in terms of its characteristics or attributes. In a recreational fishing study, for example, fishing sites might be described in terms of their catch rates, distance from home, and other characteristics. Where monetary values are sought, the cost or price of the alternatives is also included as one of the characteristics. A group of alternatives defined in this way is known as a choice set. Alternatives are distinguished by having different characteristics or attribute levels. Traditionally, in stated choice studies, respondents are asked to reveal which of the alternatives from the choice set they most prefer.

The stated choice approach is well established in the literature on environmental economics (Kanninen, 2007). It evolved from conjoint analysis, a method used extensively in marketing and transportation research (Louviere et al., 2000). Conjoint studies have most often asked respondents to rank or rate alternatives (Holmes and Adamowicz, 2003). Choice questions used in environmental economics have typically been less demanding than the conjoint questions used in marketing and transportation. Rather than asking respondents to fully rank a number of alternatives or rate them depending on their relative preferredness, they require only that respondents choose the most preferred alternative (a partial ranking) from multiple alternative goods (i.e., a choice set). This procedure seeks to capitalize on the fact that choosing the most preferred alternative from some set of alternatives is a common experience in everyday life.

Morikawa et al. (1990) note that responses to choice questions often contain useful information on tradeoffs among characteristics. Johnson et al. (1995, p. 22) note, "The process of evaluating a series of pair wise comparisons of attribute profiles encourages respondents to explore their preferences for various attribute combinations." Furthermore, Adamowicz et al. (1998a) note that the repeated nature of choice questions makes it difficult to behave strategically. As mentioned previously, choice questions allow the construction of alternatives with characteristic levels that currently do not exist.

Examples of environmental economic applications are numerous. Magat et al. (1988) and Viscusi et al. (1991) estimate the value of reducing environmental health risks; Adamowicz et al. (1994, 1998b, 2004), Breffle et al. (2005), and Morey et al. (1999b) estimate recreational site choice models for moose hunting, fishing, and mountain biking, respectively; Breffle and Rowe (2002) estimate the value of broad ecosystem attributes (e.g., water quality, wetlands habitat); Adamowicz et al. (1998a) estimate the value of enhancing the population of a threatened species; Layton and Brown (1998) estimate the value of mitigating forest loss resulting from global climate change; and Morey et al. (1999a) estimate WTP for monument preservation in Washington, DC. In each of these studies, a price (e.g., a tax or a measure of travel costs) is included as one of the characteristics of each alternative, so that preferences for the other characteristics can be measured in terms of dollars. Other examples include Swait et al. (1998), who compare prevention versus compensation programs for oil spills, and Mathews et al. (1997) and Ruby et al. (1998), who ask anglers to choose between two saltwater fishing sites as a function of site characteristics.

Alternatively, a number of environmental studies have followed a more conventional conjoint approach by using ranking or rating questions. Ranking studies present respondents with three or more alternatives and ask them to rank them from most preferred to least preferred. Rating studies ask respondents to rate the degree to which they prefer one alternative over another, often on an integer scale such as 1 to 10. Adamowicz et al. (1998b) provide an overview of choice and ranking/rating experiments applied to environmental valuation. They argue that choice questions better predict actual choices than do rating questions because choice questions mimic the real choices individuals are continuously required to make, whereas individuals rank and rate much less often.

Ultimately, the stated choice approach was clearly the preferred approach for our investigation. It enabled comparisons across a range of possible alternatives, compared to the status quo. It enabled us to investigate not just the value of avoiding shortages, but also gave us an opportunity to investigate the degree to which the severity of water use restrictions might be an important determinant in household WTP for a more reliable water supply.

## 3.2 Initial Survey Design

Initial steps in the survey design effort entailed identifying what key questions and issues were to be addressed, given a target 15-min duration survey, which we anticipated would be deployed via the Internet. The overall survey design was intended from the outset to lead up to valuation questions for water supply reliability, wherein respondents would face choice sets in which they would select a preferred option from among two or three alternatives, one of which would always be the status quo (where no further water supplies were developed to increase water supply reliability). Because each option in the choice set would have a price associated with it (an impact on household water bills), this study design would enable us to interpret the results of the choice experiments to infer a WTP for a more reliable supply.

Two key issues arose in the initial survey design phase. First, there is the challenge of presenting sufficient background information to the respondent—before the stated choice questions are reached—in a credible and readily understandable fashion. This is necessary so that the respondent can make a reasonably informed choice when faced with the task of identifying and selecting their preferred options. As can be seen from the surveys ultimately implemented, we found through focus group and one-on-one pretests that it was effective to start by providing simplified factual information about typical water use levels and patterns of households in their communities, differentiated according to whether or not the respondents had their own yards (i.e., had outdoor irrigation demands). Then information was provided on water use restrictions and their pattern in the community over the past 20 years. This set the context for how water was typically used by residential customers, how frequently restrictions on those uses had been implemented in the past 20 years, and what types of restrictions applied (i.e., less or more restrictive). This historical discussion also revealed the implications of water use restrictions (e.g., how a Stage 2 restriction could lead to dead lawns and garden plantings). This enabled us to describe future scenarios in which water shortages—and hence future water use restrictions—would likely be more frequent and/or severe. This design effectively set up the choice experiment wherein the respondent could select adding no more water supply enhancements (status quo) and endure more frequent restrictions in the future, including some periods with severe "Stage 2 restrictions."

The second key challenge was determining how to convey to respondents that water supply enhancement options would have impacts not only on the potential frequency of water use restrictions but also on the severity of these restrictions. We also wanted to convey a range of options in which it was clear that not all future water use restrictions could be avoided (i.e., no option guaranteed complete elimination of the uncertainty about future restrictions) but only the expected number of such events and/or their severity could be reduced. This suite of issues was especially important because most of the past WTP studies on water supply reliability implied elimination of shortages, leading to potential upward bias in the WTP estimates derived. The research team struggled with various approaches to portraying this multidimensional water use restriction issue in a way that would be readily understood by respondents. The use of pie charts proved—via the focus groups—to be quite effective in this regard. Respondents could understand how each choice option might impact the number and severity of future water use restrictions, and the cost of each option to them was also clear.[4]

Finally, the researchers hoped that there would be sufficient time in the survey to enable questioning respondents about their preferences across various water supply enhancement options. Fortunately, we were able to design background information and survey exercises that enabled us to assess which supply enhancement options were preferred, where the range of options included variations focusing on conservation, water reuse, desal (where applicable), increased water importation, reservoir/storage expansion, and so forth.

## 3.3 Focus Groups

Following the initial survey design, 10 focus groups were conducted to help test and refine the survey and to help tailor it to the individual characteristics of the different service areas. As the survey was first being developed, four focus groups were held before the initial survey design was completed and field implemented. Each focus group included 10 individuals recruited by a local market research firm specializing in this activity; these entities also provided the focus group facilities where participants could be viewed and the proceedings

[4] A related challenge was that initial discussions suggested that people viewed water use restrictions as the "solution" to water shortages, rather than viewing restrictions as emblematic of the "problem." We carefully cast the discussion so that water use restrictions were seen as part of the problem and that investing funds to enhance the future water supply portfolio was the solution.

recorded. Each participant received a handout with draft materials from the survey and was led through the exercises. We then engaged the participants in discussions to ensure that they understood the materials, found them credible, and were able to answer the questions based on their knowledge and preferences. An example of the focus group handout materials is provided in Appendix B.

The focus groups helped refine the initial version of the survey, for Utility X, which was the first one implemented. The subsequent success in using the survey in the field indicated that the survey design and content were functioning as intended. We then conducted two focus groups in each subsequent study location (Austin, Long Beach, and San Francisco) to ensure that local issues were properly conveyed and understood, and to identify any refinements to the survey that might enhance its clarity for respondents. Focus groups were not held in Orlando, which was the final study location.[5]

Although the main intent of the focus groups was to ensure that the survey design and supporting materials functioned properly (i.e., the materials were understood and trusted by respondents and elicited useful responses to the choice sets and other questions), the focus group format also provided several additional insights of general interest to water utilities and other water sector professionals:

- Focus group members generally had little sense of how much residential water was applied to outdoor irrigation. When shown actual statistics for their service area, most focus group members were shocked or incredulous that more than half of residential water use in most areas was directed to summer yard irrigation.
- Focus group members frequently revealed a lack of knowledge of household water use patterns, even though they tended to express a high level of awareness of the need to conserve water and an interest in taking personal actions at home to do so. For example, in almost every focus group, attendees spoke of how they now opted to wash dishes by hand rather than using their dishwashers because they believed this saved water (in fact, hand washing dishes is far more water-intensive than properly using an automatic dishwasher). In general, there was a considerable disconnect between individuals' high level of awareness, concern, and motivation to help conserve water and the lack of specific information about the most meaningful ways to do so.
- In general, when asked if they believed their household water use was similar to, less than, or greater than the amounts shown for typical area households in the handout materials, the vast majority of focus group attendees tended to believe they used less water than typical households in their area.
- Given the apparent lack of understanding by most focus group attendees of how much water they use, and for what purposes, it is clear that more and better information on water use needs to be provided to residential customers.
- The participants expressed considerable interest in obtaining "real-time" information on their water use, reflecting frustration that they did not know how much water they were using until after the bill arrived for that billing period.

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[5]No focus groups were conducted in the Orlando service area, as this site was added late in the process, and the survey had proven to be well designed through its successful application at the other four locations.

- In the initial pair of focus groups, the consequences of water use restrictions were not readily apparent to respondents. This led to adding discussion on implications in subsequent versions, so that the consequences were more evident to respondents (e.g., having one's lawn and shrubs die under a year of severe water use restrictions, or after back-to-back years of lesser restrictions on outdoor irrigation).
- Initially, the status quo (i.e., do nothing new to enhance future supplies) was portrayed as resulting in a zero ($0) increase in household water bills. Focus group participants reacted with skepticism that water bills would not increase, even if no actions were taken to enhance regional supplies. We then changed the cost of the status quo option to $1 per month ($12 per year per household) to cover increasing costs for existing water utility activities. This was seen as credible by subsequent focus group participants.
- Initially, there were several misconceptions about what "recycled water" is, and several attendees thought the issue focused on what they did in their own homes and businesses (i.e., if they recycled water within their homes). An additional description was provided in later versions to explain that recycled water, or water reuse, options referred to programs implemented at the utility level for a variety of possible uses or options [including indirect potable reuse (IPR) and traditional dual piping/irrigation uses].
- Any discussion of trying to transfer water from agricultural to municipal use was met with very strong resistance, even when the discussion was cast in terms of helping farmers save water by increasing their water use efficiency and only transferring the water savings that the urban utility paid for. This was not surprising, given the past experience of researchers regarding this subject. Nonetheless, the strength of opinion on the need to ensure that farmers get to keep their water (regardless of how inefficiently some may use it) was noteworthy.

## 3.4 Final Survey Instrument and Pretest

As described earlier, the first part of the survey presented respondents with background information on typical household water use levels and patterns in their communities, differentiated according to whether or not respondents had their own yards (i.e., had outdoor irrigation demands). Information on personal characteristics that might influence a respondent's WTP to reduce water restrictions was also collected in the first part of the survey. For example, respondents were asked whether they paid their own water bills, how they felt about the importance of increasing water supplies in their community, and whether or not they had their own yards.

Next, respondents were presented with information on different levels of water use restrictions (typically enacted during drought periods) and the requirements associated with these restrictions (such as outdoor watering only being allowed two days per week). The water use restrictions described in the surveys vary to some degree with water utility service area, based on each utility's actual water shortage or drought management plans. Table 3.1 summarizes the restrictions included in four of the five surveys conducted, by city.

In addition to the requirements associated with different levels of water use restrictions, respondents were also provided with the following information:

- A description of the impacts of various restrictions after one year and after a period of several years (e.g., after one year, Level 1 restrictions can lead to brown lawns and temporary damage to landscaping for households and public parks)
- The number of years out of the last 20 that water use restrictions had been put in place by their utility
- The number of years that restrictions would be expected to be in place over the next 20 years if no action was taken to increase water supply (the status quo)

**Table 3.1. Stage 1 and 2 Water Use Restrictions in Each City**

| | Austin | Long Beach | San Francisco | Orlando | Utility X |
|---|---|---|---|---|---|
| Stage 1 water use restrictions | Watering of lawns, gardens, and public areas with a hose-end sprinkler, a soaker hose, or drip irrigation is allowed only on designated outdoor water use days and must occur before 10:00 a.m. and after 7:00 p.m.<br>Watering of lawns, gardens, and public areas with a permanently installed automatic irrigation system is allowed only on designated days and must occur between midnight and 10:00 a.m.<br>Watering of lawns, gardens, and public areas with a hand-held hose or a hand-held bucket can occur at any time.<br>Home vehicle washing using a hand-held bucket or hose with a shutoff nozzle is allowed only on designated days and must occur before 10:00 a.m. and after 7:00 p.m.<br>Water is served in restaurants only upon request. | Landscape watering is only allowed two days per week (Monday and Thursday after 4:00 p.m. and before 9:00 a.m.), year-round.<br>Filling residential swimming pools and spas with drinking water is not allowed. | All customers receive a monthly allotment of water based on past indoor and outdoor water use. Customers using more than the allotted amount pay “excess use” charges and may be subject to having devices installed on their water service line that will restrict the flow of water to their homes.<br>Examples of additional water use restrictions include<br>• The use of water to clean sidewalks, patios, and other hard surfaces may be prohibited<br>• Water suitable for drinking may not be used for decorative fountains<br>• The use of additional water may not be allowed for new landscaping unless low-water-use landscaping designs and irrigation systems are employed<br>• Water-saving fixtures or devices may be required in all new construction | All water users must reduce their water use by 15% from the most recent year that water shortage restrictions were not in effect. Specific measures include<br>• All water users are required to test and repair their irrigation system to address sources of water waste<br>• Lawn and landscape irrigation is restricted to one day per week on designated days, between the hours of 6 p.m. and 9 a.m.<br>• Cisterns, hand-watering, and low-volume irrigation systems may be used at any time<br>• The use of water for fountains and other decorative displays is not allowed<br>• The local water utility may implement additional measures as necessary | Apply when water supplies are projected to be 65% of normal for the summer.<br>Lawns, gardens, and public parks cannot be watered more than twice a week and for no more than 15 min per zone. Enforcement is focused on severe and repeated violations. |

**Table 3.1—*Cont.***

| | Austin | Long Beach | San Francisco | Orlando | Utility X |
|---|---|---|---|---|---|
| Stage 2 water use restrictions | Watering of lawns, gardens, and public areas is allowed only with a handheld hose or a handheld bucket, is limited to designated outdoor water use days, and must occur between 6:00 a.m. and 10:00 a.m. and between 7:00 p.m. and 10:00 p.m.<br>No use of automatic irrigation systems.<br>No vehicle washing.<br>No operation of outdoor ornamental fountains or structures making similar use of water, other than the aeration necessary to preserve habitat for aquatic species.<br>No filling of swimming pools, fountains, or ponds.<br>No installation of new landscaping. | Most outdoor water use would not be allowed.<br>Additional water use restrictions may be put in place by the LBWD as necessary. | Additional water use prohibitions and restrictions would be implemented, and customers would be subject to an increased level of rationing. Most outdoor watering would not be allowed. | All water users must reduce their water use by 20% from the most recent year that water shortage restrictions were not in effect. Specific measures include:<br>Lawn and landscape irrigation is *prohibited*. Irrigation of child playgrounds and sports fields is allowed one day per week.<br>Cisterns, hand watering, and low-volume irrigation systems may be used at any time to water nonturfgrass material.<br>Washing or cleaning of vehicles is limited to one day per week and must be done using low-volume methods (including at car washes).<br>Washing or cleaning of buildings and outdoor surfaces is generally not allowed.<br>The local water utility may implement additional measures as necessary. | Apply when water supplies are projected to be 40% of normal for the summer.<br>Require that lawns, gardens, and public parks cannot be watered at all, but trees can be watered by hand. Enforcement is strict for all violations. |

Respondents were then presented with three sets of choice questions in order to evaluate their preferences for a range of possible programs to reduce (to varying degrees) different levels of water use restrictions over the next 20 years. Each choice set allowed respondents to choose the program called “No Additional Actions,” or the status quo alternative. The experimental design for this study comprised 24 programs with varying levels of use restrictions. For each choice set, two of the programs were randomly selected. Once a program was selected in any of the choice questions for a given participant, it was not selected again in future choice questions (i.e., no replacement of programs). This allowed us to get three choice-set data observations for each respondent. Figure 3.1 provides an example survey choice set.

In addition to the stated choice questions, respondents were also asked about their preferences for different options that water suppliers in their region could undertake to improve future water supply reliability. Options presented in all surveys included

- Increasing available supplies of water by transferring more water from agricultural uses
- Increasing the price of water to residential, commercial, and industrial users so that they will use less
- Requiring low-water-use landscaping (e.g., Xeriscape) in new homes and redevelopment projects
- Expanding the use of recycled water for outdoor irrigation and industrial uses
- Promoting voluntary water conservation through education and incentives (e.g., rebates for homes that switch to low-water-using appliances or landscaping)

In each survey, a water import option was also presented that involved importing surface water from outside the region or river basin.

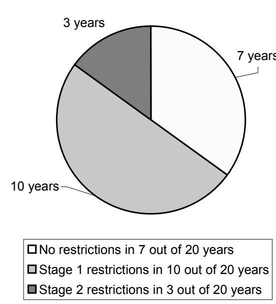
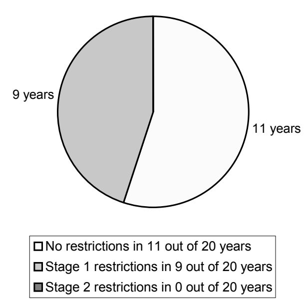
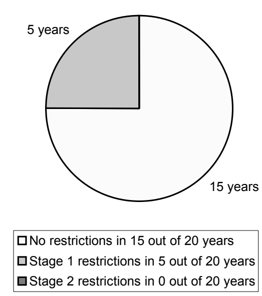
| | No additional actions | Plan B | Plan C |
|---|---|---|---|
| Available water supply such that water use restrictions in the next 20 years will be |  |  |  |
| Increase in your water cost | $1 per month, which would be $12 per year | $14 per month, which would be $170 per year | $25 per month, which would be $300 per year |
| | | | |
| Which plan do you prefer? | ☐ | ☐ | ☐ |

**Figure 3.1. Example choice set.**

Additional alternative options presented in different cities included

- Expanding water recycling to replenish groundwater reservoir supplies (Austin, Long Beach, Orlando, and San Francisco)
- Investing in regional desal facilities to convert ocean, bay, or brackish waters into part of the local drinking water supply in some regions (Long Beach, San Francisco, and Orlando)
- Increasing available water supplies by expanding or adding new storage reservoirs (Austin, Orlando, and San Francisco)
- Increasing the use of nonlocal groundwater sources (Austin and Long Beach)
- Increasing the use of local groundwater sources (Austin and Orlando)
- Increasing available supplies in dry years by acquiring more imported water in wet years and storing it underground for local use in dry years (Long Beach and Orlando)

For each option, a brief description, including advantages and disadvantages, was provided. Respondents were then asked to rank their five most preferred options, as well as their least preferred option. Following this section of the survey, individuals were presented with a series of questions asking them to indicate two relatively similar supply options (e.g., two recycled water options or two water conservation options). Examples of these questions from the Long Beach survey are included in Figure 3.2.

## 3.5 Survey Implementation and Sampling Methods

Knowledge Networks (KN, part of the Stratus Consulting project team) administered the online water supply reliability survey to 2115 individuals within the Austin, LBWD, Orlando, Utility X, and SFPUC service areas. A total of 298 people responded to the survey as part of the KnowledgeNetwork Internet Panel; the remaining sample was supplemented using another Internet panel (e-Rewards). To ensure that all respondents received their water from the participating water utilities, Stratus Consulting provided KN with a list of ZIP codes that were completely contained within the utility service areas. Survey weights were generated by KN to adjust for sample design, noncoverage, and nonresponse biases. These weights were used in the analysis in order to generalize results to residents of specific ZIP codes who participated in the study.

## 3.6 Economic Model and Willingness-to-Pay Analysis

Economists use a variety of models to analyze the type of data collected with the choice questions used in this survey. A well-accepted and straightforward model often applied is the conditional logit model, which we employed for our analysis. This model is an extension of the multinomial logit model and is particularly appropriate for choice behavior models. As a simple description, conditional logit models estimate the probability that an individual will make a given choice based on different explanatory variables including attributes of the choice alternatives (e.g., cost of the water supply reliability program) and characteristics of the individuals making the choice (such as age and income). Figure 3.3 provides a description of the theory behind choice models, in general, and conditional logit models, specifically.

**Does It Matter How We Reduce Future Water Shortages?**

There are different ways that water suppliers can provide the same amount of water supply in the future. The next few questions ask you to choose among options that could be implemented to reduce the frequency of water shortages in the future. For each of the following questions, please indicate which option you prefer.

**Q17. Of the two underground water storage options below, which do you prefer?**

| | |
|---|---|
| Increasing underground storage of recycled water | 1 |
| Increasing underground storage of imported water in Wet years | 2 |

**Q17a. Of the two groundwater options below, which do you prefer?**

| | |
|---|---|
| Increasing use of local groundwater sources through replenishing the basin | 1 |
| Increasing use of non-local groundwater sources and pumping The water to Long Beach | 2 |

**Q18. Of the two water transfer and import options below, which do you prefer?**

| | |
|---|---|
| Increasing water imports from MWD | 1 |
| Increasing water transfers from agriculture | 2 |

**Q19. Of the two water conservation options below, which do you prefer**

| | |
|---|---|
| Requiring low-water landscaping in new homes | 1 |
| Promoting additional voluntary water conservation through Education and incentives | 2 |

**Q20. Of the two water recycling options below, which do you prefer? Note that because new piping is necessary for outdoor irrigation and industrial uses, expanding water recycling for outdoor irrigation and industrial uses costs three times as much as expanding water recycling to replenish groundwater supplies.**

| | |
|---|---|
| Expanding water recycling for outdoor irrigation and industrial uses | 1 |
| Expanding water recycling to replenish local Groundwater supplies | 2 |

**Figure 3.2. Questions regarding preferences for similar water supply options, as illustrated in the Long Beach version of the survey.**

The analysis of multiattribute stated choice data typically involves statistical techniques based on random utility maximization (RUM) models (Haab and McConnell, 2002). The specific econometric techniques include discrete choice models such as logit and probit or more complex mixed logit or rank-ordered probit models. RUM models are used to estimate respondents' WTP to achieve particular levels of water supply reliability (or other applicable attributes). The tradeoff between monetary payments and reliability attributes provides the estimate of WTP for the changes. For example, responses to choice questions in the survey may indicate that people are willing to pay a specified increase in water bills if water shortages and water use restrictions in the future are reduced to a specified level.

Suppose that $Y_i$ represents a discrete choice among $J$ alternatives. Let $U_{ij}$ represent the value or *utility* of the $j$th choice to the $i$th individual. We will treat the $U_{ij}$ as independent random variables with a systematic component $h_{ij}$ and a random component $e_{ij}$ such that

$$U_{ij} = h_{ij} + e_{ij}. \tag{3.1}$$

We assume that individuals act in a rational way, maximizing their utility. Thus, subject $I$ will choose alternative $j$ if $U_{ij}$ is the largest of choice set $U_{i1}$, $U_{iJ}$. Note that the choice has a random component, since it depends on random utilities. The *probability* that subject $I$ will choose alternative $j$ is

$$p_{ij} = \Pr\{Y_i = j\} = \Pr\{\max(U_{i1}, U_{iJ}) = U_{ij}\}. \tag{3.2}$$

It can be shown that if the error terms $e_{ij}$ have standard Type I extreme value distributions with

density $f(e) = \exp\{-e - \exp(-e)\}$, (3.3)

then

$$p_{ij} = \exp\{h_{ij}\} / \exp\{h_{ik}\}, \tag{3.4}$$

which is the basic equation defining the multinomial logit model.

Luce (1959) derived Equation 3.5 starting from a simple requirement that the odds of choosing alternative $j$ over alternative $k$ should be independent of the choice set for all pairs $j, k$. For example, if $A$ is preferred to $B$ out of the choice set $\{A,B\}$, then introducing a third alternative $X$, which thus expands the choice set to $\{A, B, X\}$, must not make $B$ preferable to $A$. In other words, preferences for $A$ or $B$ should not be changed by the inclusion of $X$; i.e., $X$ is irrelevant to the choice between $A$ and $B$.

**Figure 3.3. General choice models.**

*Source:* Rodriguez, 2009.

### 3.6.1 Conditional Logit Model

In analyzing stated choices, economists assume that the differences across respondents' choices are attributable to variation in both observed characteristics (e.g., respondents' demographic characteristics and/or responses to survey questions) and unobserved, random variation. Our model includes several variables to account for the variation in observed characteristics of a choice. For example, we include the cost of the alternative associated with a given choice. We also define two attributes as the number of fewer restriction years relative to the "no-action" scenario for each restriction level. Finally, we include personal characteristics, including education, age, income, a dummy variable indicating whether or not the respondent believes increasing water supplies is of high or low importance, the amount of time living in the city where the survey was implemented, a dummy variable indicating yard ownership status, and a dummy variable indicating whether or not a respondent pays his or her own water bill. The personal characteristics are interacted with a dummy variable indicating whether or not the choice decision concerns an alternative to the status quo (e.g., whether the respondent chose Plan B or Plan C over the No Additional Actions alternative). This provides variability to the data and allows the model to estimate the impact of personal characteristics on choosing an alternative to the no-action scenario.

The following equation shows the general structure of the conditional logit model used in this analysis. On the left-hand side of the equation is the probability that an individual (with given characteristics) will choose an alternative to the status quo. On the right-hand side of the equation are the variables upon which this choice depends. In the model, the estimated value of the beta coefficients represents the extent to which each variable contributes to the choice:

$$
\begin{aligned}
P = \; & \beta_1(\text{Cost per year}) + \beta_2(\text{Reduction in Level 1 restrictions}) \\
& + \beta_3(\text{Reduction in Level 2 restrictions}) + \beta_4(\text{Chose alternative} \\
& \times \text{education}) + \beta_5(\text{Chose alternative} \times \text{age}) + \beta_6(\text{Chose alternative} \\
& \times \text{income}) + \beta_7(\text{Chose alternative} \times \text{increasing water supplies} \\
& \text{important}) + \beta_8(\text{Chose alternative} \times \text{time living in Long Beach}) \\
& + \beta_9(\text{Chose alternative} \times \text{own yard}) + \beta_{10}(\text{Chose alternative} \\
& \times \text{pay water bill}). \qquad (3.7)
\end{aligned}
$$

The conditional logit model described here assumes a constant (i.e., linear) WTP for reductions in restriction years. Additional statistical analyses were conducted to explore potential nonlinear effects of changes in restriction years on WTP (i.e., to explore whether the anticipated reduction in marginal WTP is observed as the number of avoided restrictions declines). These more complex empirical analyses were aimed to better examine how the WTP estimates may be influenced by the total number of years of restrictions avoided (rather than assuming each year is valued equally, regardless of how many total years have use restrictions eliminated). The results of this evaluation revealed no statistically significant difference between the linear results reported earlier and the nonlinear variations we estimated.

### 3.6.2 Willingness to Pay to Reduce Water Use Restrictions

To estimate WTP to reduce water restrictions by one unit (i.e., one year), we divide the model coefficients for the number of fewer level 1 restrictions and the number of fewer level 2 restrictions each by the model coefficient for the cost variable. This provides the marginal WTP to reduce Level 1 and Level 2 water restrictions, respectively. WTP results and additional findings from the survey are provided in Chapter 4.

*Chapter 4*

# Empirical Results

This chapter summarizes the empirical results of our analysis, including key findings related to

- Preferences for alternative water supply programs to improve water supply reliability compared to the status quo (i.e., doing nothing to increase future water supplies)
- WTP to avoid future water restrictions
- Preferences for different types of water supply sources

The following sections provide an overview and comparison of results in each city. Detailed results for each study location are provided in Appendices D–H.

## 4.1 Preferences for Alternative Water Supply Programs

As described in Chapter 3, the stated preference valuation portion of the survey included a series of three choice questions. For each question, respondents were asked to choose between the status quo (i.e., the utility not taking any additional actions to bolster the reliability of its current water supply portfolio) and two alternative options for increasing future water supply reliability. The two alternative options included in each choice question were randomly selected from a set of 24 options, which vary based on the annual cost to the customer, the number of years that future water use restrictions would be in place, and the severity of those use restrictions. The annual cost of the 24 alternative water supply options ranged from $20 to $300 per household, and the cost of the status quo option was $12 per year above the current household annual water bill.

Under the status quo (no additional action) option, the scenario was presented as a projection that no water use restrictions would be needed in 7 of the next 20 years; Level 1 restrictions would be in place in 10 of the next 20 years; and Level 2 restrictions would be in place in 3 of the next 20 years. We applied a very similar status quo option scenario across all five of the surveyed service areas to develop a consistent basis for comparing results across regions (i.e., so that respondents essentially faced the same baseline and future choices, regardless of location). Under the alternative options, the number of Level 1 and/or Level 2 restriction years is reduced compared to the status quo. The Level 1 and Level 2 restrictions are very similar across regions, but the language in the surveys was tailored to better reflect each local utility's specific policies.

Table 4.1 displays the percentage of the time respondents in each city chose the status quo option over the other alternatives presented in their choice questions. The number of observations underlying these percentages is equal to three times the number of respondents, as each respondent was presented with three choice questions. As shown, respondents in Long Beach and Orlando chose the status quo option at a much higher rate than respondents in other cities. In Austin, San Francisco, and Utility X, respondents chose the status quo option about 50% of the time.

**Table 4.1. Percentage of Time Status Quo Option Was Chosen as the Preferred Option, by City**

| City | Percentage of Time Status Quo Option Was Chosen (%) |
|---|---|
| Austin | 45.4 |
| Long Beach | 61.7 |
| Orlando | 63.2 |
| San Francisco | 50.7 |
| Utility X | 48.3 |

To evaluate preferences across the 24 alternatives, we calculated the percentage of respondents who chose a given alternative when it was presented to them (i.e., of the respondents who were presented with Version X, Y% chose Version X over the status quo and the other version presented). Although this analysis does not address the variation of alternative versions presented to respondents, it does provide feedback about respondent responses to each alternative. Table 4.2 presents the alternative most frequently chosen in each city and the characteristics associated with that alternative, including annual cost to the customer (in addition to the regular water bill) and the number of years that Levels 1 and 2 restrictions would be in place (for reference, characteristics associated with the status quo alternative are also shown).

As shown in Table 4.2, the most frequently chosen alternative in Long Beach and San Francisco (Alternative 10) is more expensive than the most frequently chosen alternative in other cities. Alternative 10 would reduce the number of Level 2 restriction years by 3 (i.e., eliminate all expected Level 2 restrictions over the next 20 years) and the number of Level 1 restriction years by 2 relative to the status quo option. Although Alternative 10 is more expensive than the most frequently chosen alternatives in other cities, within the context of all 24 alternatives (with costs ranging from \$20 to \$300), Alternative 10 is relatively inexpensive, with 16 other options being more expensive.

Overall, cost seems to be a larger factor in the decision to select a given alternative than the decrease in the number of fewer restriction years that an alternative would provide. This is exemplified in Figures 4.1–4.5, which show the correlation between the cost of each alternative (not including the status quo) and the percentage of respondents who chose that alternative (when it was presented to them), as well as the correlation between the number of (weighted) fewer restriction years[6] under each alternative and the percentage of respondents who chose that alternative.

[6]The decrease in the number of Level 2 restriction years was assigned a weight of 3 to represent the significance respondents placed on reducing Level 2 restrictions compared to Level 1 restrictions, which are much less severe.

**Table 4.2. Most Frequently Chosen Alternative to the Status Quo, by City**

| City | Most Frequently Chosen Alternative | Summers with No Restrictions | Summers with Level 1 Restrictions | Summers with Level 2 Restrictions | Added Cost per Year | Percentage Chosen, % |
|---|---|---|---|---|---|---|
| | Status Quo | 7 (8)[a] | 10 (8)[a] | 3 (4)[a] | $12 | |
| Austin | Alternative 24 | 10 | 9 | 1 | $65 | 53.8 |
| Long Beach | Alternative 10 | 12 | 8 | 0 | $110 | 37.0 |
| Orlando | Alternative 5 | 10 | 8 | 2 | $60 | 37.2 |
| San Francisco | Alternative 10 | 12 | 8 | 0 | $110 | 39.6 |
| Utility X | Alternative 2 | 12 | 6 | 2 | $95 | 47.0 |

[a]Expected future is the same in all cities with the exception of Austin, which is shown in parentheses.

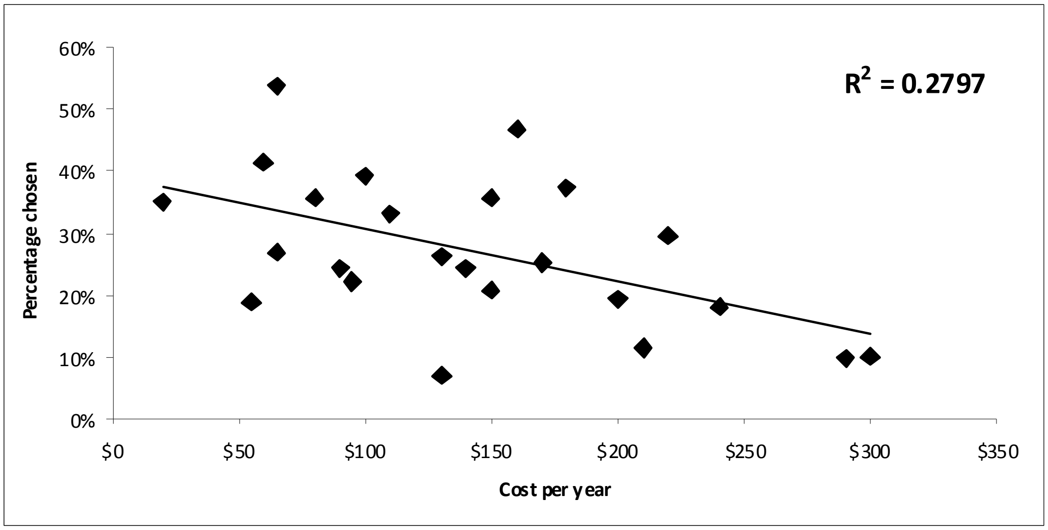
As shown in Figures 4.1–4.5, in all cities, there is a strong correlation between the cost of the alternative and the percentage of respondents who chose that alternative. This result indicates that cost is a much more important driver in the selection of alternatives across all cities, compared to reducing restriction levels.

## 4.2 Willingness to Pay to Avoid Water Use Restrictions

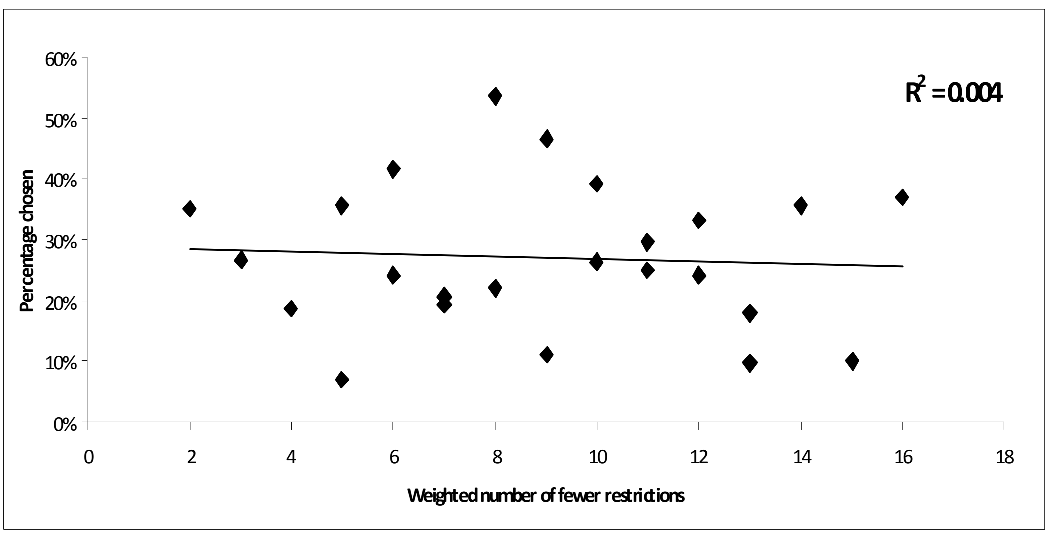
Based on the choices made by respondents, we are able to infer respondent WTP to avoid water use restrictions using a conditional logit model (see Chapter 3). This type of model is used to estimate the probabilistic effect of a choice attribute (e.g., cost of a water supply program) or personal characteristic (e.g., age, income, level of education) on the outcome of a given choice. The following sections discuss the choice attributes and individual characteristics that seem to influence WTP to avoid water use restrictions and provide mean annual WTP estimates for each study area.

### 4.2.1 Choice Attributes and Respondent Characteristics Influencing Choice Decisions

Because a respondent's choice is contingent on observed and random respondent characteristics, our model includes several variables to account for the variation in observed characteristics of a choice. First, we included the cost of the alternative associated with a given choice. We also defined two attributes as the decrease in the number of restriction years relative to the status quo for each restriction level. Finally, we used personal characteristics, including education, age, income, a dummy variable indicating whether the respondent believes increasing water supplies is of high or low importance, the amount of time lived in the service area, a dummy variable indicating yard ownership status, and a dummy variable indicating whether or not a respondent pays his or her own water bill. The personal characteristics are interacted with a dummy variable indicating whether or not the choice decision concerns an alternative to the status quo. This provides variability in the data and allows the model to estimate the impact of personal characteristics on choosing an alternative to the status quo.

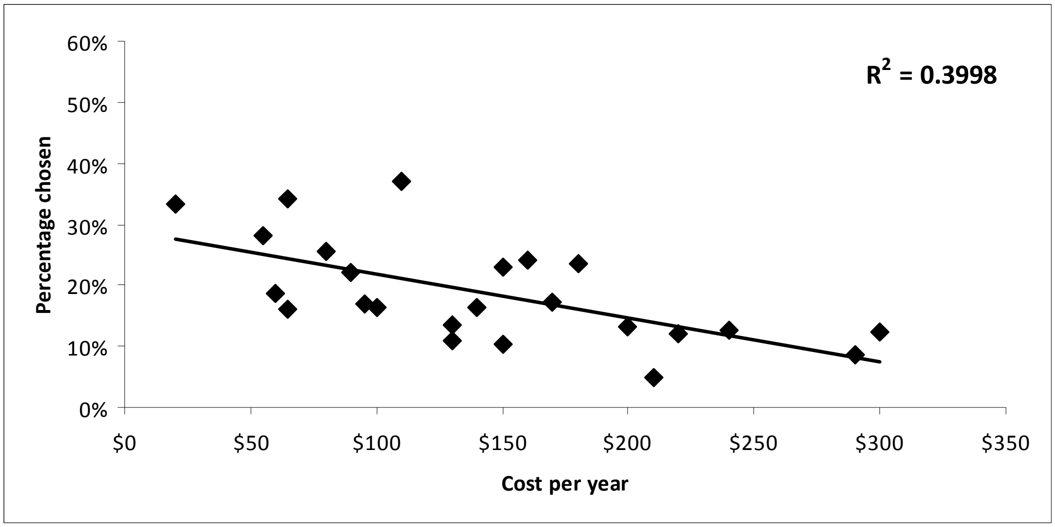



**(a)**

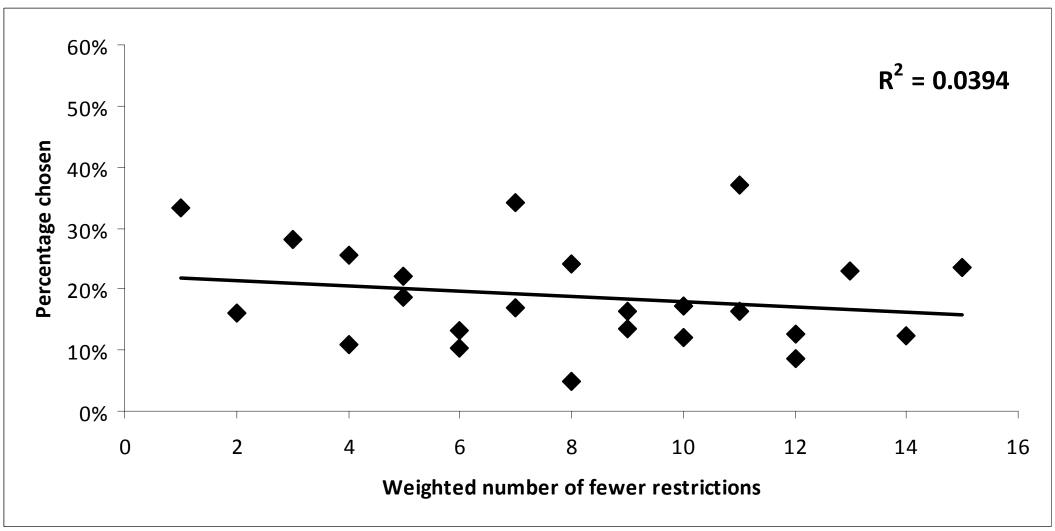



**(b)**

**Figure 4.1. Austin: Alternative selection by (a) cost of alternative and (b) number of (weighted) fewer restriction years.**

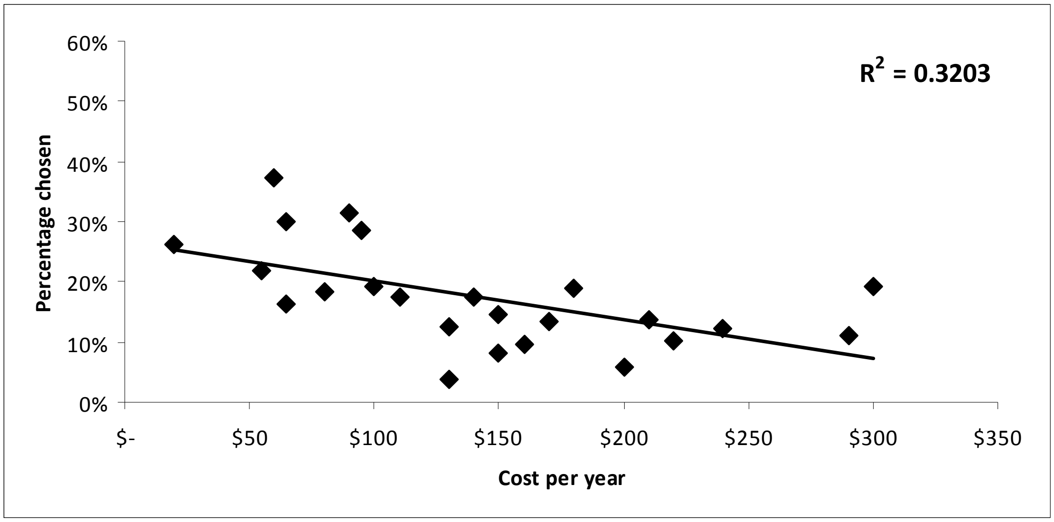



**(a)**

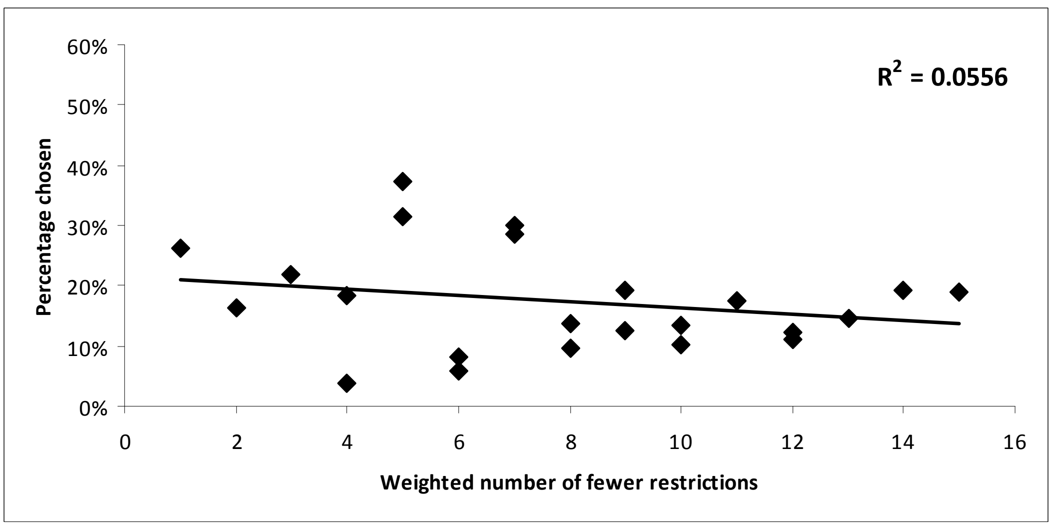



**(b)**

**Figure 4.2. Long Beach: Alternative selection by (a) cost of alternative and (b) number of (weighted) fewer restriction years.**

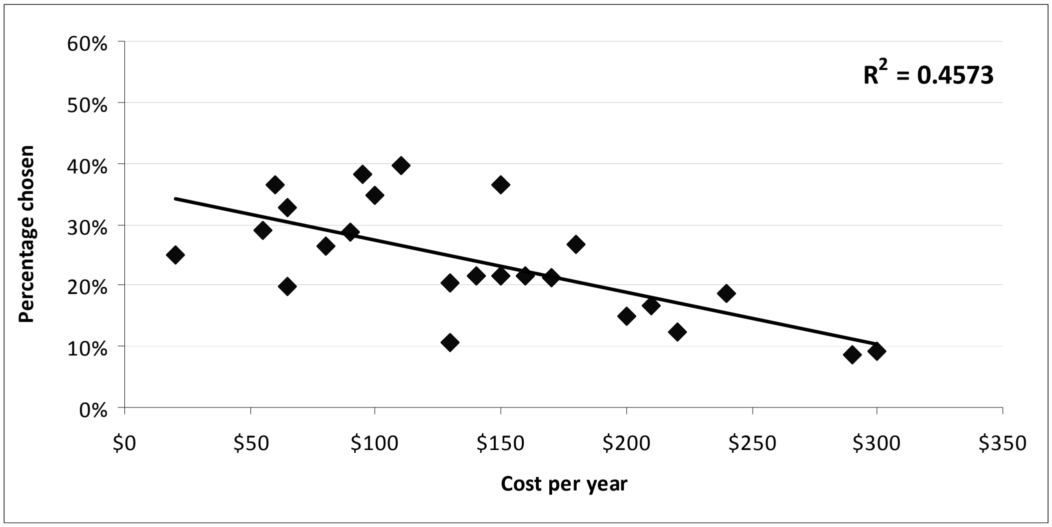



**(a)**

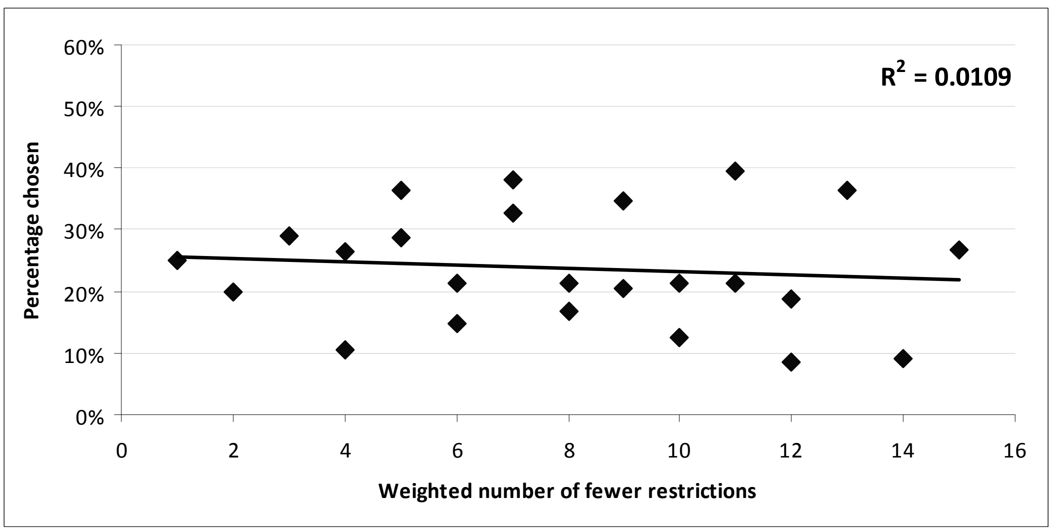



**(b)**

**Figure 4.3. Orlando: Alternative selection by (a) cost of alternative and (b) number of (weighted) fewer restriction years.**

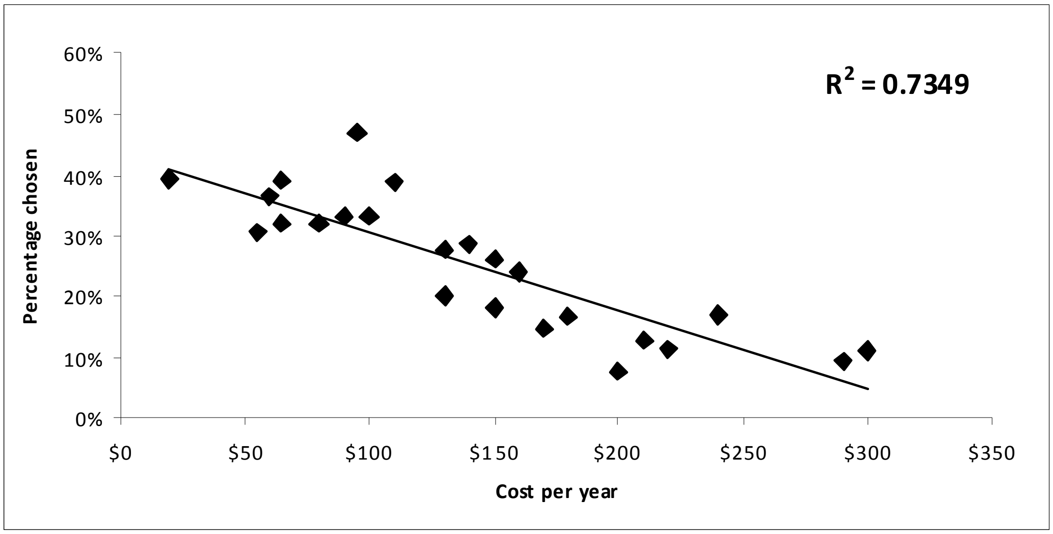



**(a)**

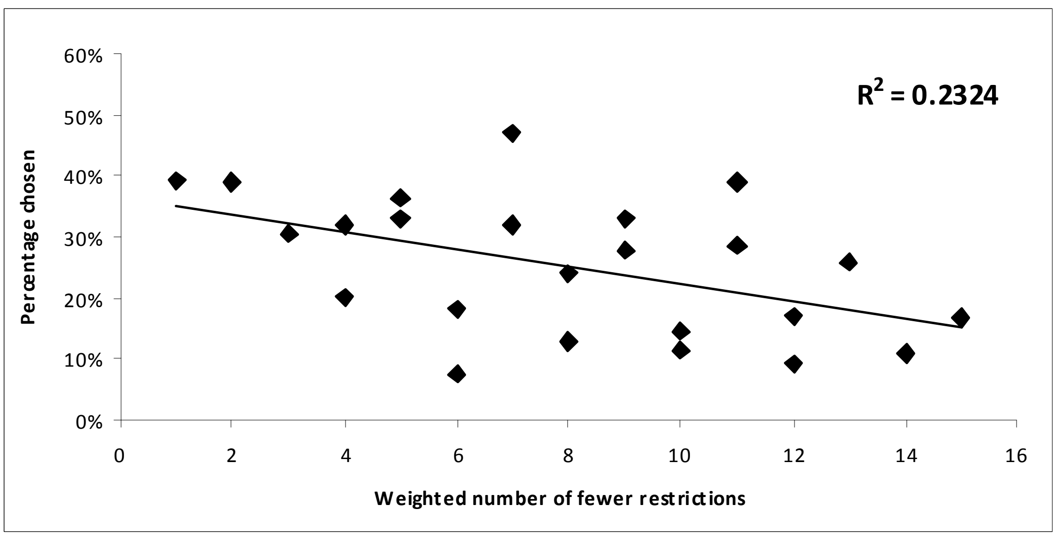



**(b)**

**Figure 4.4. San Francisco: Alternative selection by (a) cost of alternative and (b) number of (weighted) fewer restriction years.**




(a)




(b)

**Figure 4.5. Utility X: Alternative selection by (a) cost of alternative and (b) number of (weighted) fewer restriction years.**

Table 4.3 shows respondent characteristics that were found to statistically influence a respondent's likelihood of choosing an alternative to the status quo in each city.[7] The relationship between a given characteristic and the choice of an alternative to the status quo is described by the positive and negative indicators in the table. For example, the positive indicator for education in Austin means that respondents with higher levels of education are more likely to choose an alternative to the status quo (and thus are willing to pay more to reduce water use restrictions) than their less-educated counterparts. Relationships are reported for those variables that are statistically significant from zero in the models estimated.

As expected, cost has a negative impact on the likelihood of choosing a given option (i.e., as cost increases, the likelihood of choosing an alternative to the no-action scenario decreases) in every city. In Austin, Long Beach, Orlando, and Utility X, the number of fewer restriction years relative to the no-action scenario for Level 1 restrictions does not significantly affect WTP. This means that most individuals are not willing to pay to reduce Level 1 restrictions.

Education is found to have a positive impact on the choice of an alternative in both Austin and San Francisco. Household income positively influences the choice of an alternative in Austin, Orlando, and Utility X, but does not significantly influence this choice in Long Beach or San Francisco. Individuals in Austin and Long Beach who believe increasing water supplies is an important issue in their region are also more likely to choose an alternative to the status quo, and thus are willing to pay more to reduce future water use restrictions.

In Long Beach and Utility X, age negatively affects an individual's likelihood of choosing an alternative, meaning that the older a respondent is, the less he or she is willing to choose an alternative or pay to avoid restrictions. Time spent living in the area also negatively affects the likelihood of choosing a given option in Austin, Orlando, and San Francisco, meaning that the longer a respondent has lived in the city, the less he or she is willing to pay for an alternative that would reduce restrictions. Finally, in Long Beach, respondents who pay their own water bill are less likely to choose an alternative to reduce restrictions compared to individuals for whom water costs are embedded in rental costs or homeowner association fees.

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[7]As part of this analysis, we also evaluated the potential for combining the individual datasets in order to develop one model. First, we implemented a Chow Test. The Chow Test is a method well known in econometrics that can be used to analyze the same variables obtained in two different datasets to determine if they are similar enough to be pooled together. The results of the Chow Test indicated that we would be able to pool the datasets for Austin, San Francisco, and Utility X, but not the datasets for Long Beach and Orlando. The results of the combined model were consistent with results from these individual cities. However, notably, the number of fewer Level 1 restriction years became significant due to the strong significance in San Francisco, and the near significance of Level 1 restrictions in Utility X (significant at the 11% level). This indicates that people are willing to pay to reduce Level 1 restrictions. Other variables that were significant and positive in the combined model include the number for fewer Level 2 restrictions, education, income, and the importance respondents place on increasing water supplies. Time spent living in the community was the only negative and significant variable.

**Table 4.3. Respondent Characteristics Influencing the Likelihood of Choosing an Alternative to the Status Quo[a]**

| | Austin | Long Beach | Orlando | San Francisco | Utility X |
|---|---|---|---|---|---|
| Cost per year | - | - | - | | - |
| Reduction in Level 1 restrictions | | | | + | |
| Reduction in Level 2 restrictions | + | + | + | + | + |
| Education | + | | | + | |
| Age | | - | | | - |
| Household income | + | | + | | + |
| Increasing water supplies is of high importance | + | + | | | |
| Time living in city | - | | - | | |
| Own a yard | | | | | |
| Pay water bill | | - | | | |

[a]Relationships are reported for those variables that are statistically significant at the 5% level.

In addition to the characteristics shown in Table 4.3, we also evaluated whether ethnicity plays a role in the choice of an alternative. In some cities, the small sample size for different ethnic groups makes it difficult to draw concrete conclusions. However, it is clear that relationships between ethnicity and the likelihood of choosing an alternative vary across cities. For example, in Long Beach, our model showed a statistically significant difference between Caucasian and African American respondents, and between Caucasian and Hispanic respondents. In both cases, Caucasian respondents were more likely to choose an alternative to the status quo. In Utility X, Hispanic respondents were less likely to choose an alternative than Caucasian and African American respondents in their community.

To account for small sample sizes, we compared Caucasian respondents to non-Caucasian respondents in each city, grouping all non-Caucasian respondents into one category. We found that in almost every city, Caucasian respondents were more likely to choose an alternative to the status quo compared to their non-Caucasian counterparts. This relationship was positive and statistically significant in all cities except for Austin. In Austin, Caucasian respondents were not found to be statistically different from respondents in their communities with different ethnic backgrounds.

**Table 4.4. Residential Customer Annual Willingness to Pay**

| | Austin | Long Beach | Orlando | San Francisco | Utility X |
|---|---|---|---|---|---|
| WTP to reduce Level 1 restrictions by 1 year out of the next 20[a] | | | | \$12.25 | |
| WTP to reduce Level 2 restrictions by 1 year out of the next 20 | \$33.94 | \$34.29 | \$20.20 | \$37.16 | \$20.55 |

[a]The WTP estimates for reducing Level 1 restrictions are not statistically significant from zero in Austin, Long Beach, Orlando, and Utility X (i.e., respondents are not willing to pay to reduce Level 1 restrictions) and are therefore not reported in this table.

### 4.2.2 Mean Annual Willingness-to-Pay Estimates

Using the parameter estimates from the conditional logit model, we calculated annual WTP measures for reducing Level 1 and Level 2 restrictions. Table 4.4 presents the estimated mean annual WTP for a one-summer reduction in each restriction. The WTP estimates for reducing Level 1 restrictions are not statistically significant from zero in Austin, Long Beach, Orlando, or Utility X (i.e., respondents are not willing to pay to reduce Level 1 restrictions) and are therefore not reported in Table 4.4. The mean WTP for reducing Level 2 restrictions by 1 summer out of the next 20 is positive and statistically significantly different from zero in all cities. These results imply a positive WTP by respondents for increasing water reliability to avoid Level 2 restrictions.

As shown in Table 4.4, respondents in San Francisco are willing to pay the most to reduce drought restrictions. Respondents in Orlando and Utility X are not willing to pay as much as respondents in other cities. This is likely attributable to differences in the experiences and attitudes of residents in these locations.

To interpret these results in the context of understanding the mean household WTP for specific water supply enhancement programs, one needs to add the mean values based on the number and type of restrictions the program is expected to eliminate. For example, in the Long Beach survey, the next 20 years were portrayed as yielding an anticipated 7 years with no restrictions, 10 years with Level 1 restrictions, and 3 years with Level 2 restrictions. Suppose an ambitious supply enhancement program was expected to eliminate imposition of all the projected Level 1 and Level 2 use restrictions. The mean annual WTP results shown in Table 4.4 suggest that the total household WTP for this program would be [($0 × 10) + ($34.29 × 3)] = $102.87 per year. This conclusion assumes a constant WTP for reductions in restriction years.

## 4.3 Customer Preferences for Different Types of Water Supply Enhancement

The following sections present findings from the survey related to the types of water supply projects that customers think their utility should pursue to expand and enhance their existing supply portfolios.

### 4.3.1 Most Preferred Water Supply Enhancement Options

Respondents were asked to rank a series of different options that water suppliers in their region could undertake to improve future water supply reliability. In each city, 9 or 10 choices were presented on the survey. Options presented in all surveys included

- Increasing available supplies of water by transferring more water from agricultural uses
- Increasing the price of water to residential, commercial, and industrial users so they will use less
- Requiring low-water-use landscaping (e.g., Xeriscape) for new homes and redevelopment projects
- Expanding the use of recycled water for outdoor irrigation and industrial uses

- Promoting voluntary water conservation through education and incentives (e.g., rebates for homes that switch to low-water-using appliances or landscaping)
- Adopting a water import option that involved importing surface water from outside the region or river basin

Additional alternative options presented in different cities included

- Expanding water recycling to replenish groundwater reservoir supplies (Austin, Long Beach, Orlando, San Francisco)
- Investing in regional desal facilities to convert ocean, bay, or brackish waters into part of the local drinking water supply (Long Beach, San Francisco, Orlando)
- Increasing available supplies of water by expanding or adding new storage reservoirs (Austin, Orlando, San Francisco)
- Increasing the use of nonlocal groundwater sources (Austin, Long Beach)
- Increasing the use of local groundwater sources (Austin, Orlando)
- Increasing available supplies in dry years by acquiring more imported water in wet years and storing it underground for local use in dry years (Long Beach, Orlando)

For each option, a brief description, including advantages and disadvantages, was provided. Respondents were then asked to rank their five most preferred options. Figure 4.6 shows the percentage of respondents who ranked a given option as one of their top three choices.

As shown in Figure 4.6, in Long Beach, Orlando, and San Francisco (results from the survey conducted within the Utility X service area are not reported here because of confidentiality agreements), the three most preferred water supply options included expanding the use of recycled water for outdoor irrigation and industrial purposes, promoting additional voluntary conservation measures through education and incentives, and requiring low-water-use landscaping for new development and redevelopment projects. Compared to the other cities, a higher percentage of respondents in San Francisco selected these options as one of their top three choices. In Austin, although results were similar, respondents ranked using recycled water to replenish groundwater as one of their three most preferred options more frequently than requiring low-water-use landscaping.

Figures 4.7–4.10 show specific results for the top three water supply options in each city.

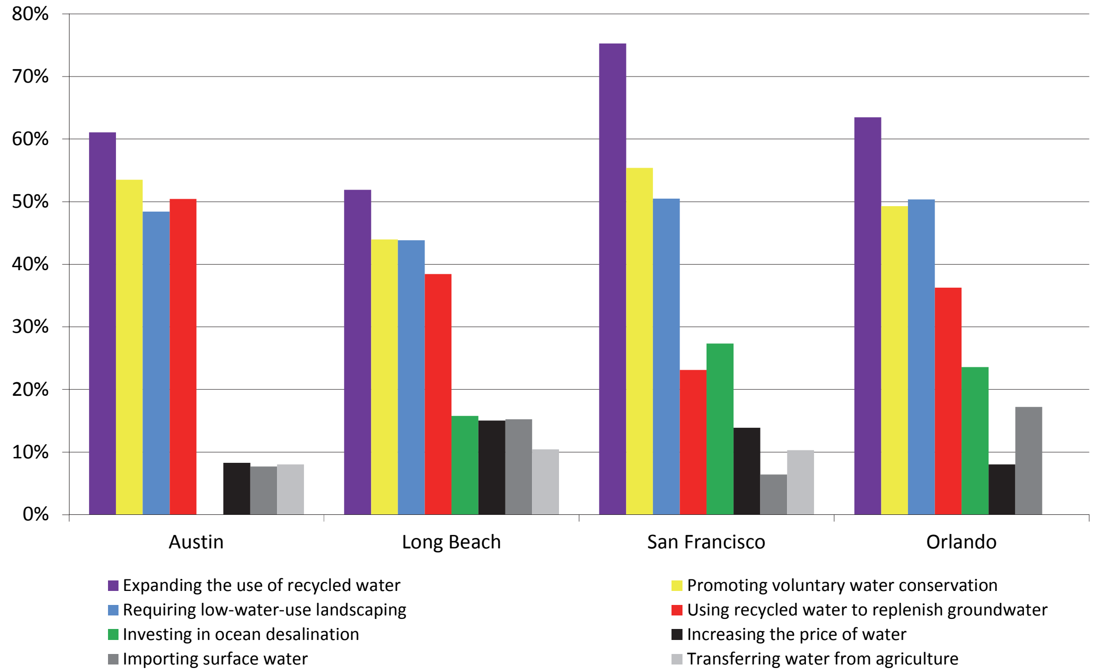


**Figure 4.6. Percentage of respondents, by city, who selected a given option as one of their three most preferred options for water supply enhancement.**

### 4.3.2 Least Preferred Water Supply Enhancement Options

As a follow-up to the ranking of various supply enhancement options, we asked respondents to choose their *least* preferred option of the remaining unranked choices. Figure 4.11 shows that in most cities surveyed, “increasing the price of water so that customers will use less” is the least-preferred option among respondents. In San Francisco, a slightly greater number of respondents chose “importing new surface water supplies outside the Bay Area” as their least preferred option. Importing surface water from outside the region or river basin was the second least preferred option in Austin and Long Beach. “Increasing available supplies of water by transferring more water from agricultural uses to urban areas” also seems to be a relatively unpopular option in most cities.

Interestingly, in San Francisco, about 13% of respondents chose investing in regional desal facilities as their least preferred option. However, close to 26% of respondents chose desal as one of their three most preferred options.

## 4.4 Summary

Overall, the survey results indicate that in most cities, customers are willing to accept some level of water use restrictions (e.g., limiting irrigation of lawns and landscape to two days per week). However, customers are willing to pay to avoid more severe restrictions (e.g., prohibition of the irrigation of lawns and landscape). Annual WTP values to avoid these more severe restrictions ranged from $20 (Orlando and Utility X) to about $37 (San Francisco).

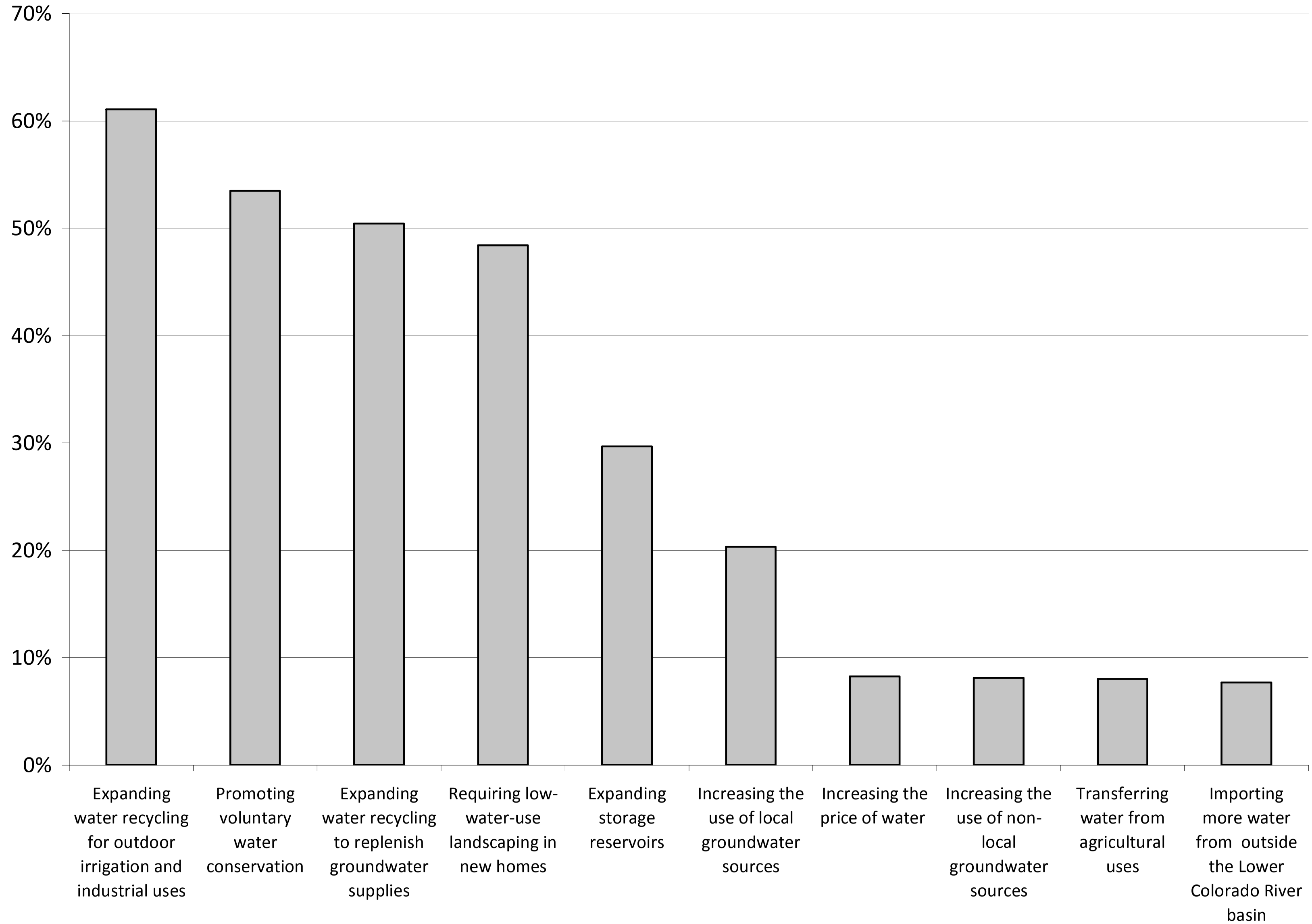


**Figure 4.7. Percentage of respondents selecting a given option as one of their top three choices for water supply enhancement: Austin.**

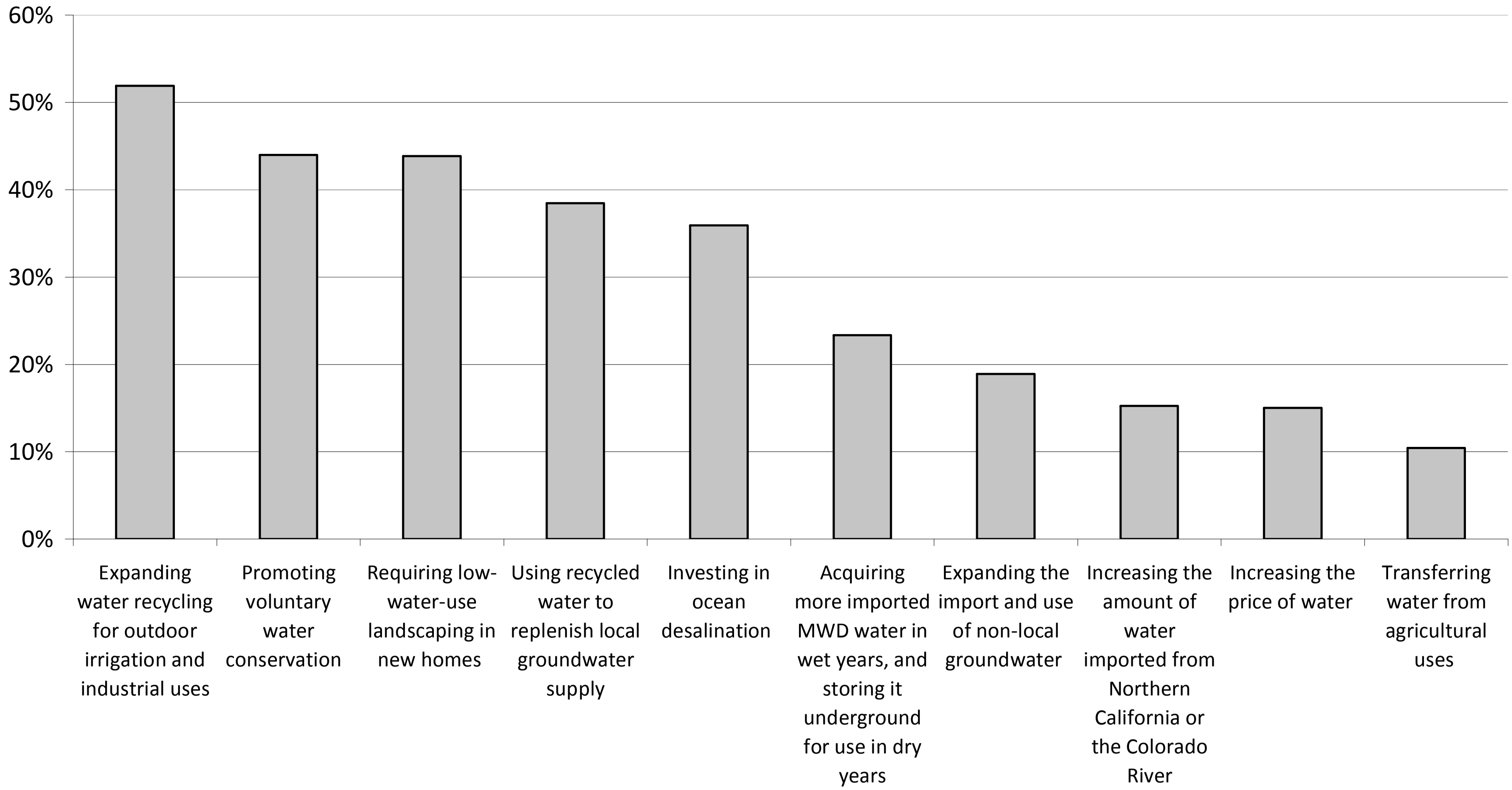


**Figure 4.8. Percentage of respondents selecting a given option as one of their top three choices for water supply enhancement: Long Beach.**

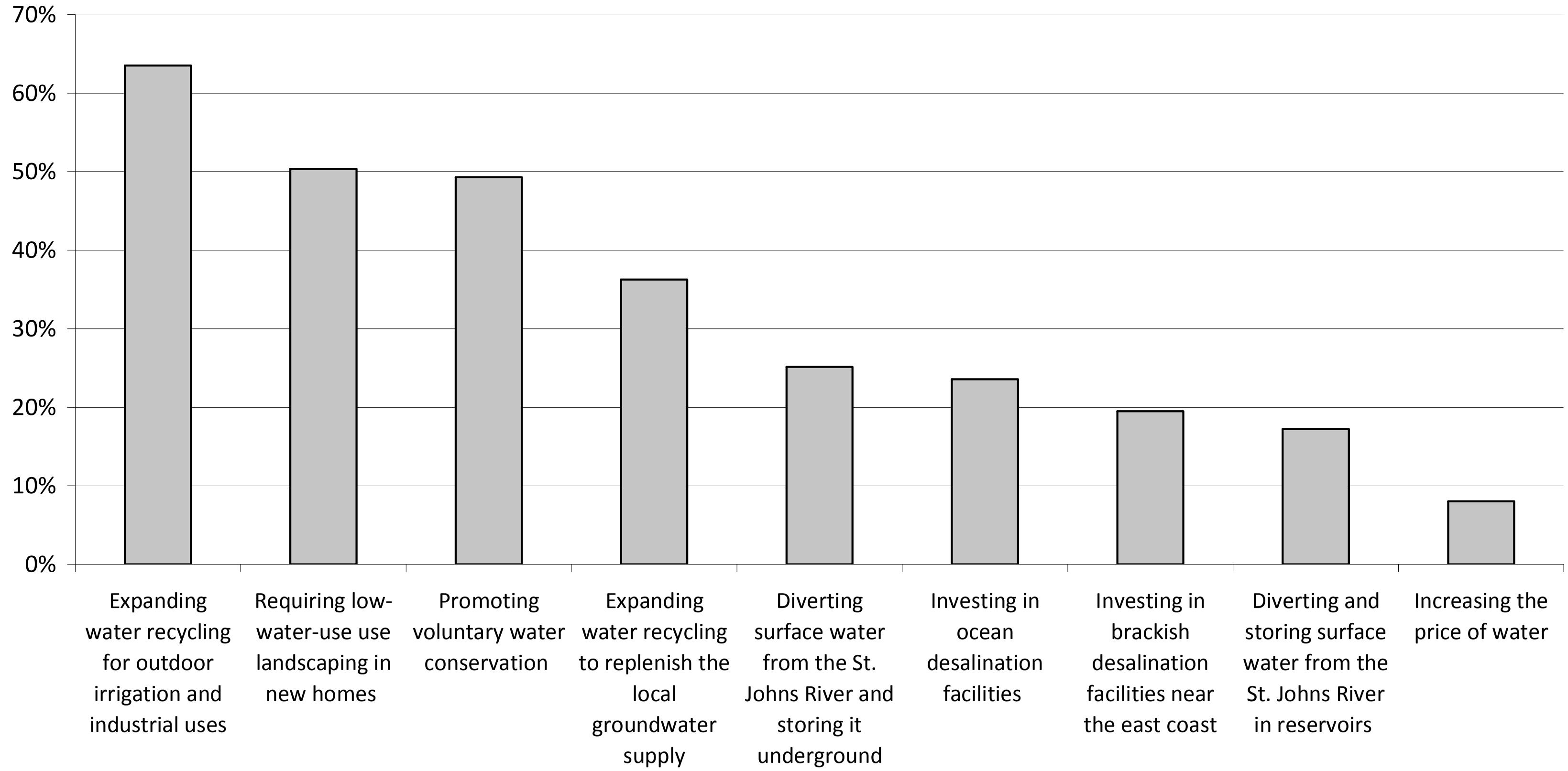


**Figure 4.9. Percentage of respondents selecting a given option as one of their top three choices for water supply enhancement: Orlando.**

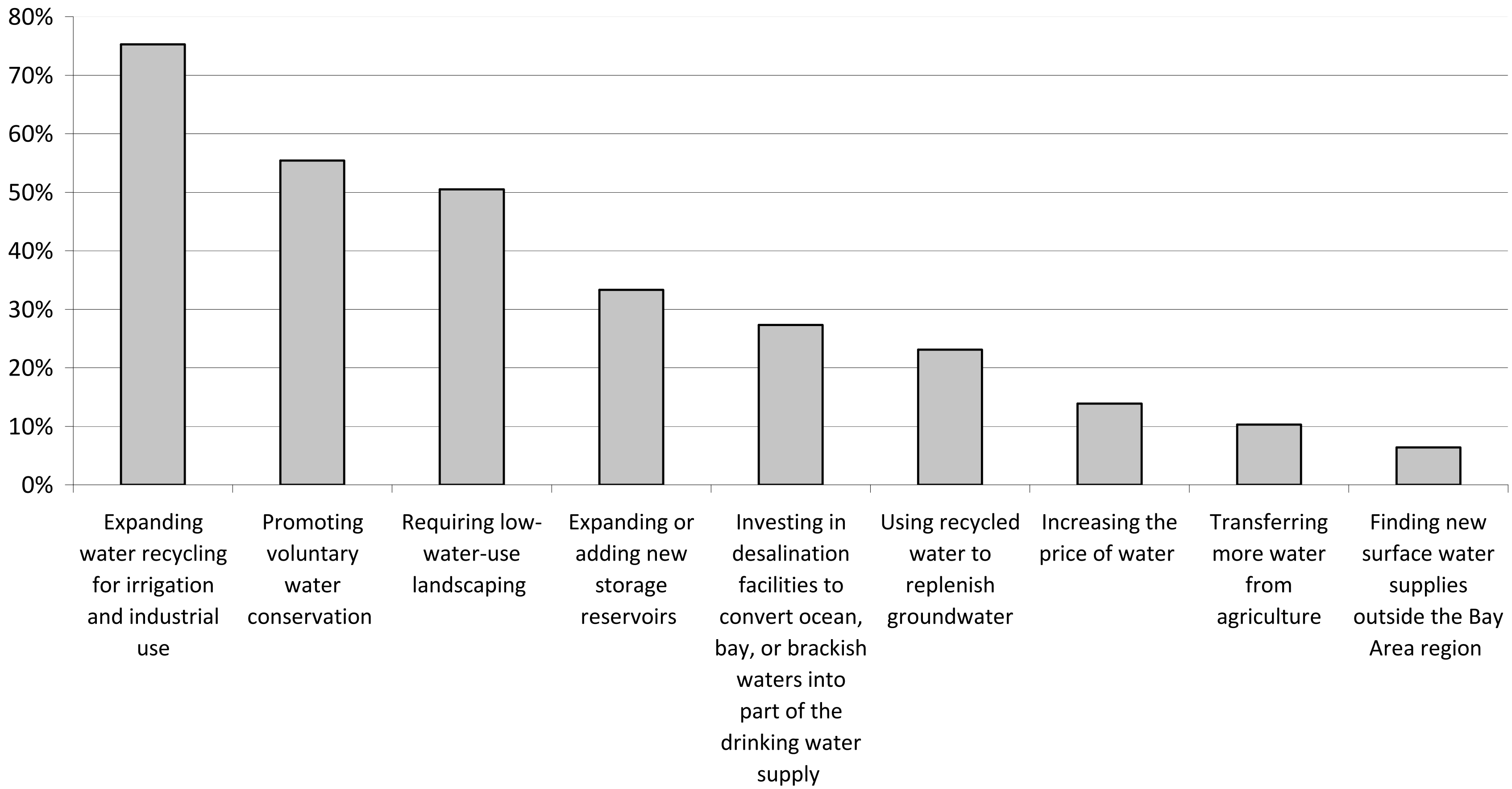


**Figure 4.10. Percentage of respondents selecting a given option as one of their top three choices for water supply enhancement: San Francisco.**

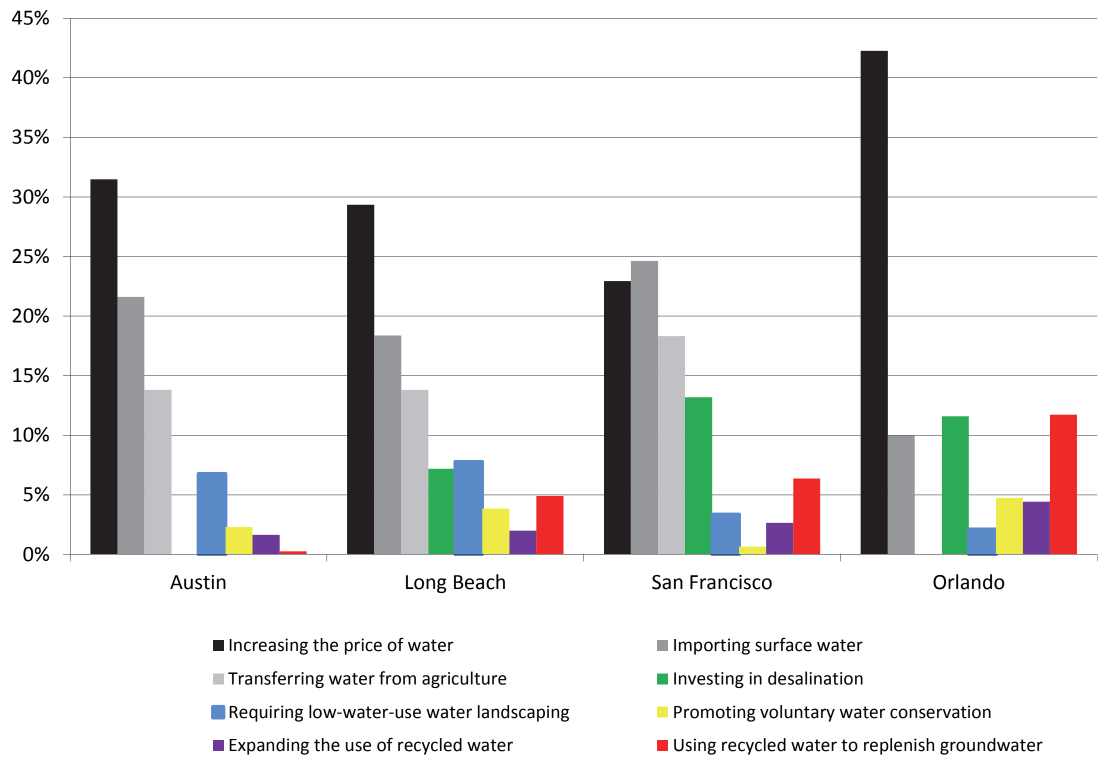


**Figure 4.11. Percentage of respondents, by city, and their least preferred option rankings.**

The most preferred water supply options in Long Beach, Orlando, and San Francisco included expanding the use of recycled water for outdoor irrigation and industrial purposes, promoting additional voluntary conservation measures through education and incentives, and requiring low-water-use landscaping for new development. About 27%, 24%, and 15% of respondents in San Francisco, Orlando, and Long Beach, respectively, also chose investing in regional ocean desal facilities as one of their three most preferred options. Close to 17% of respondents in Orlando chose investing in brackish groundwater desal facilities as one of their three most preferred options. In Austin, nonpotable use of reclaimed water was also a top choice, and more respondents chose using recycled water to replenish groundwater supplies (i.e., IPR) than requiring low -water-use landscaping as one of their three most preferred options.

*Chapter 5*

# Interpreting and Applying the Empirical Findings

This chapter summarizes the key empirical survey results and provides guidance on how these outcomes may be interpreted within the context of water utility planning. First, some general, qualitative observations are offered, based on the results derived from our survey efforts. Then, specific empirical findings are discussed with regard to how they might be interpreted and applied.

Also provided in this chapter is general guidance for utilities that may be interested in using or refining our survey instrument (or developing their own surveys) to assess customer attitudes and WTP for water supply reliability and water supply enhancement options.

## 5.1 General Observations and Interpretations

As described in Chapter 4, several empirical findings were consistently observed across the utility service areas in which customers were surveyed. Although these findings may not necessarily apply to customers in a specific utility, the consistency of findings across the five regions suggests that the preferences expressed may be consistently held in many other geographical areas. These general observations are discussed in the following paragraphs.

> *1. Residential customers consistently reveal a positive WTP to improve the reliability of their water supply in order to avoid relatively severe water use restrictions.*
>
> The estimated WTP to avoid Stage 2 water use restrictions was statistically significant (in terms of being statistically different from zero) in all five regions and ranged from $20.20 per household per year (Orlando) to $37.16 per household per year (San Francisco). These values reflect the WTP of households each year to avoid one year of Stage 2 restrictions at some point over the next 20 years. Complete results are provided in Chapter 4 (Table 4.4).
>
> Given that the scenarios evaluated in the survey reduced the projected number of Stage 2 restrictions by up to 3 years, the WTP to avoid all Stage 2 restrictions over the 20-year period ranged from $60.60 to $111.48 per household per year. These per household annual WTP values are consistent with the lower-end values derived by the earlier WTP studies described in Chapter 2 (e.g., typically near to or more than $100 per household per year). However, the earlier studies typically implied a level of certainty for avoiding all restrictions. Consequently, we expect the WTP responses from those studies to be greater than the responses derived in our current empirical work, because our approach allows choices that do not eliminate all Stage 2 or Stage 1 restrictions (i.e., our approach has households purchasing less certainty regarding the elimination of restrictions than most of the older studies).

*2. Residential customers tend to view low-level water use restrictions as an acceptable inconvenience and generally express a low WTP to avoid such water supply shortages.*

The estimated WTP to avoid Stage 1 water use restrictions was typically quite low and was not statistically significant in four of the five regions (San Francisco being the one exception, where a statistically significant WTP of $12.25 per household per year to avoid a future year of Stage 1 restrictions was derived). This suggests that customers generally are willing to accept periodic imposition of low-level Stage 1-type restrictions, seeing them as a periodic inconvenience rather than an event necessitating significant financial investment in supply enhancement. This result is consistent with the findings from the Australian survey efforts that used choice experiments (Hensher et al., 2006; Tapsuwan et al., 2007).

This finding also supports policies under which utilities consider imposing Stage 1-type restrictions before water supplies reach critical levels, as a risk-avoiding, proactive effort to preclude the need for more restrictive Stage 2 policies later. That is, having more frequent and/or longer-duration imposition of Stage 1 restrictions may be warranted if this conservation of water helps reduce the likelihood that Stage 2 restrictions will be needed later.

*3. Water reuse options, including IPR options, appear to have a high level of customer support.*

In each service area, survey respondents were provided with an opportunity to review a list of 9 or 10 water supply enhancement options and to rank their top five preferences. We then determined which options were selected as the top choices. Because respondents may not have a significant degree of preference among their top three options (i.e., we do not know the strength of preference for a top choice relative to the second and third preferred options), we believe an examination of the options that tended to be selected in the top three preferred choices provides a reliable indication of general preference.

As shown in Chapter 4, in each of the five service areas, the option to expand water reuse for outdoor irrigation and industrial use was most frequently selected as one of the top three alternatives. Hence, the expanded use of recycled water for nonpotable uses (e.g., via purple pipe) was the most popular choice in each region.

The use of recycled water to replenish local groundwater (i.e., IPR) was also considered very favorably. As noted previously, it was the second most popular option in one region, and was ranked third, fourth (twice), and fifth—out of 10 options—in the other regions. This is a somewhat surprising show of public acceptance, given concerns often raised by some water sector professionals about potential or anticipated public opposition to IPR.

The other options that tended to rank relatively high as preferred water supply enhancements were those related to conservation, especially the option promoting voluntary efforts supported by rebates.

*4. Raising water rates and importing more water from outside the service area were typically the least preferred options.*

The survey also was used to elicit opinions on which options customers preferred the least (based on respondents being shown the options that they did not rank in their top five and being asked to select their "least preferred" of those four or five unranked alternatives). As shown in Chapter 4, the options that were consistently listed as least popular were raising the price of water to promote use of less water and importing more water from outside the region (or importing waters transferred from agricultural users).

The high degree of dislike for the option of using price as a rationing mechanism is noteworthy, especially when one considers that respondents also expressed a significant WTP to invest in water supply enhancements to reduce the frequency of water shortages and associated use restrictions. This adds strength to the WTP estimates because even though customers have a strongly expressed disapproval of rate increases to conserve water, they are nonetheless willing to pay to enhance supplies when this reduces the likelihood (frequency) of severe water use restrictions.

The general disapproval of water import options is also interesting and suggests a preference for solving local water issues with local resources (which in turn may enhance or explain the expressed support for water recycling options). Discussions within the focus groups about water importation options often generated statements reflecting concern over taking someone else's water and the desire or need to solve local water issues with local resources. Taking water from farmers was also widely rejected, and focus group discussions on this topic tended to reflect concern over actions that might impair farmers' ability to produce food crops (even though the option was framed as paying to improve agricultural water use efficiency, and only transferring the water saved).

## 5.2 Empirical Interpretation and Application

There are two basic approaches to using the empirical information developed from our survey research. One is to use the basic survey instrument, refine and test it so that it best reflects circumstances relevant to the local service area, and then implement the site-specific revised survey within the service area. This approach will typically provide the most reliable and utility-specific information. However, it will require an investment of time and resources to modify, pretest, and implement the survey and to analyze the data collected. Guidance on how to proceed with this process is provided later in this chapter.

The second approach to using the empirical information obtained in our research is through a method called "benefits transfer." In essence, this approach entails assuming that the empirical results presented here are indicative of the types of WTP values customers served by a utility have. This requires much less effort and little funding. However, the results may be less reliable, to the degree that customers and/or local water supply circumstances differ from those in the five utilities included in our investigation.

### 5.2.1 Applying Values Derived from This Study

The empirical WTP findings from this study are statistically significant and fairly consistent across service areas. Hence, they may be taken as a range to reflect household WTP for water supply reliability. More specifically, it seems reasonable to infer that, on the average, households have expressed a WTP to avoid one year of Stage 2-type severe water use restrictions that is on the order of $20 to $37 per household per year.[8]

Several important "standard practices" should be followed in applying these values in a BT context. First, you need to determine whether the study population (the 2000 + respondents to our survey) is similar to the service area population in your region. Are there reasons to believe that customers in your service area may be different in important ways from those who responded to our survey? For example, are they richer or poorer than the study population? Have they had similar exposure to and experiences with periodic imposition of water use restrictions? Do they have larger or smaller yards and outdoor irrigation needs or habits?

Second, one needs to consider if the water shortage and water use restriction scenarios applicable to your utility are similar to those characterized for the service areas surveyed. If there are similar stages defined for potential water use restrictions, similar histories of their deployment, and similar likelihood of future frequencies, then the scenarios evaluated in our work are probably similar enough to your utility's circumstances. If water shortages in your region are likely to be appreciably different in terms of likelihood and impact, then the results from our survey efforts are unlikely to be applicable to your utility's situation.

If there is reasonable confidence that BT is suitable, then apply the range of values to the number of households served by your system, adjusted for the number of Stage 2-type restrictions that you estimate are likely to be avoided over the relevant time horizon (e.g., three avoided Stage 2-like restrictions being imposed over the next 20 years). This provides a rough estimate of the potential dollar value of your residential customer sector, in terms of how much customers are willing to pay for supply-enhancing investments that will likely enable your utility to avoid those shortfalls. For example, if you are evaluating an option that you believe would preclude three years that otherwise would have resulted in Stage 2 restrictions and you serve 25,000 households, then the lower end of the range would be $1.5 million per year ($20 per household per year × 25,000 households × 3 years of severe restrictions avoided).

Another perspective can be attained by interpreting the household WTP estimates in terms of the value per unit of water provided (e.g., dollar per acre-foot). A rough approximation can be derived by calculating the per household amount of water use enabled by avoiding the restrictions (or, stated alternatively, the volume of water saved by imposing the restrictions) and comparing that with the household WTP estimate.

For example, in Utility X, the mean WTP estimate to avoid one year of Stage 2 restrictions is $20.55 per household. The amount of additional water use reduction from moving from Stage 1 to Stage 2 restrictions is estimated by Utility X to be 15%. Per household water use

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[8]We strongly recommend using the full range of values, rather than selecting a single dollar value for WTP.

for homes with yards is typically 340 gallons per day, or 38% of an acre-foot per year. A 15% reduction under Stage 2 restrictions thus amounts to 5.7% of an acre-foot of water use foregone per household (15% of 38%). A household WTP of $20.55 each year for 20 years has a present value of $250, when discounted at 6%. This $250 is the WTP to avoid losing use of 0.057 acre-feet in one future year. Therefore, the implied value to the household for that water use is $4386 per acre-foot ( = $250/0.057 acre-foot).[9]

### 5.2.2 Revising and Applying the Survey Instrument to Your Service Area Customers

If you are interested in applying this survey to residential customers in your area, we recommend that you adhere to the accepted best practices for survey design and implementation that are described in the following paragraphs.

> *1. Review and revise the survey instrument* to best reflect your local circumstances. For example, apply water use data from your system, describe your water use restrictions as they have been applied or would apply in the future (though simplifying as needed to not overload or confuse respondents), show past and projected frequencies of water use restrictions as most applicable to your setting, and describe the water supply enhancement options that are most applicable to your region. For the choice experiments, use the 24 options we drew randomly if they all are suitable given your past history and projected future conditions. Otherwise, develop a suite of alternative future program options with costs and restriction frequencies that are internally consistent.
>
> *2. Conduct focus groups* to ensure that local customers understand the information provided to them. Focus groups should be recruited to reflect a representative sample, and facilitated by an experienced professional. Focus groups are essential to ensure that typical customers find the choices relevant and realistic, and can complete the tasks imposed on them in the survey (e.g., in the choice experiment portion, ensure that they understand what information the pie charts convey and can make informed choices between the status quo and the one or two alternatives presented to them). Focus groups also are invaluable to help find and apply the right words that resonate with laypeople rather than technical jargon that utility professionals use routinely.
>
> *3. Pretest the survey* by applying it to a small sample of the general public in a controlled setting. This step often adds value, especially when one-on-one debriefings are held with the pretesters, who can explain what they may have found confusing or other problems. Refine and repeat as necessary.
>
> *4. Implement the survey in the field* (i.e., collect data). Our survey was designed specifically for application over the Internet, using a representative sample of the general public from the Knowledge Networks Internet Panel. This approach provides many advantages, including the ability to have a more interactive survey. For

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[9]This is similar to the result derived in Raucher et al. (2006, Appendix D) in terms of evaluating the WTP results from the older stated preference studies as dollar per acre-foot values. There, the Griffin and Mjelde (2000) WTP results were shown to imply a value of roughly $4900 per acre-foot (updated to 2011 dollars).

example, a response can be used to steer the respondent to the next appropriate follow-up question, or respondents can be prompted to go back when they missed a question or failed to successfully complete the assigned task (e.g., rank options). The Internet-based approach also produces a very high response rate, eliminates coding errors, and enables extremely fast data collection turnaround. However, this approach can be costly (e.g., at least $25,000 for a target of 400 completed surveys), requires retaining a reputable Web-based survey firm, and may be limited by the size of panel sample available within a defined utility service area.

Alternative modes for survey implementation are mail and telephone. There are drawbacks to both approaches, such as low response rates, long implementation periods to successfully gather data from a sufficient sample size, data entry needs, associated labor expense, and the potential for introducing errors. Telephone surveys also provide less representative samples from the general public because fewer people retain landlines (and those who do tend to be elderly). Also, with caller identification and the prevalence of marketing calls, fewer people are willing to answer the telephone and complete a complex 20-minute survey. In addition, the survey will need some redesign to accommodate implementation by telephone or mail (e.g., to preselect the options provided in the choice experiments, with different respondents receiving a preselected suite from which to choose).

*5. Analyze the data carefully and apply them prudently.* The data require sophisticated statistical analysis, and specialized expertise may be needed for effective analysis. Also, be careful when interpreting the data (e.g., it may be tempting to overreach, using results that lack statistical significance). Strongly consider retaining a suitable expert as an independent reviewer to assess all aspects of the project effort, including the results and how they will be applied.

For all these steps, it may be prudent to retain outside, specialized expertise to guide you through the process, from recruiting and hosting focus groups, to developing the sampling strategy and implementing the survey, to analyzing the data.

## 5.3 Conclusions

The empirical findings derived from this study are generally robust and provide useful information. In particular, it is evident that households in the sampled areas of the United States have a significant WTP to enhance the local water supply portfolio to reduce the likelihood of severe water use restrictions in some future years (although there is much less inclination to pay for programs that reduce the frequency of less severe water use restrictions). There is thus an empirically demonstrated value for enhanced water supply reliability, and the guidance and illustrations provided here facilitate the practical use of these findings by water agencies.

There also are very interesting and robust results with respect to customer preferences for options they would opt to pursue to enhance the utility's water supply portfolio. Water reuse consistently was among the top choices, even the IPR options, and conservation was also widely popular. In contrast, raising water rates to prompt less water use, water importation, and transfers from agriculture were generally viewed unfavorably.

*Chapter 6*

# Suggested Future Research

Based on our research and the empirical results obtained, three follow-up research needs were identified to improve our understanding of reliability values. The following is a description of those needs.

*1. Repeat and update the empirical effort in two to four years.*

The results from the current study will be greatly enhanced and will retain their applicability if the survey effort is periodically updated and implemented, perhaps every two to four years. For example, our results are probably strongly influenced by the difficult economic climate most Americans were facing during the data collection period (last half of 2010 and first half of 2011). Once the economy improves, it will be instructive to determine if WTP for water supply enhancements increases when unemployment and fiscal worries are less prevalent among residential customers. In addition, it will be very instructive to observe how attitudes, preferences, and WTP may be impacted by different water scarcity conditions. How will respondents' WTP and supply preferences change if they have recently experienced more severe water shortages and use restrictions (or when they have just enjoyed relatively wet years)?

Finally, it will be useful to apply the updated versions of the survey to new regions and to repeat the effort in some regions that were previously investigated. Expanding the survey effort to new regions will enable us to see how WTP and attitudes vary across different parts of the nation and will facilitate the use of survey results by more utilities. Repeating the survey effort in a few already-surveyed service areas will enable us to discern trends over time within the same service area population (e.g., Have they changed their WTP? Have they modified their preferences regarding alternative water supply options? If so, why?).

*2. Investigate the basis for and strength of supply option preferences more closely.*

The survey provided very interesting, useful, and somewhat surprising results in terms of how strongly the respondents consider water recycling (including IPR) to be one of their most preferred reliability-enhancing options. This is very encouraging for the water reuse community, and additional work would enable us to more closely explore the basis and strength of the apparent high level of public support for reclamation. How much of the stated support expressed in our empirical results stems from having the other parts of the survey establish a suitable context (i.e., establishing the need to enhance water supply portfolios in order to reduce the likelihood and severity of future shortages), rather than discussing water reuse in more abstract terms (e.g., apart from the need to make a choice to solve a problem)? How will the provision of additional facts and issues potentially alter the level of support (e.g., pharmaceuticals and personal care products)?

The public preference for water reuse provides an important opportunity for the reuse community. More work should be done to strengthen our knowledge of the basis of those preferences and how they can be maintained and strengthened.

*3. Investigate reliability values beyond the residential sector.*

This research effort has focused exclusively on the value of water supply reliability to residential customers (i.e., households). It will be valuable to extend this line of empirical inquiry to other customers, notably those in the CII sectors.

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*Appendix A*

# Reviewing the Literature and Establishing Context

This appendix summarizes literature related to valuing water supply reliability enhancement projects. First, we articulate the difference between WTP estimates (which focuses on the *value* of increasing or maintaining a target level of reliability) and the water supply "portfolio theory" (which provides a basis for adjusting the *cost* of maintaining a given reliability target).

Second, we provide a comprehensive review of the literature related to the value of water supply reliability. Given the nature of this research, we focus primarily on studies that have attempted to value WTP for improved reliability (or WTA a decrease in the level of reliability) using "stated preference techniques." For each study reviewed, we present key findings and provide an overview of study methodology. We also provide a brief assessment of utility-sponsored customer survey efforts (primarily from our participating utilities) that shed light on reliability-related attitudes and values for residential customers.

A primary objective of this review is to evaluate the methodology (including advantages and disadvantages associated with each approach) and results from the existing literature, which typically originate from 10 or more years ago when customer preferences, economic status, and drought experiences were different, and economic methods were less reliable. Findings from this evaluation served as a key input into the study (and survey) design for the current research.

## A.1 Valuing Reliability of Water Supply

Utility managers and others recognize that maintaining or improving the reliability of their water supply yield is likely to be highly valued by their communities. However, the absence of suitable customer valuation data makes these reliability benefits difficult to quantify in a meaningful and credible manner. This impedes decision-making for long-term water supply investments because these investments are increasingly expensive. Thus, utility managers (and their governing Boards) typically desire credible information to assess whether the value (benefit) of water supply reliability investments are high enough for their customers to warrant the potential rate increases needed to pay for them.

There are two distinct tracks that can be used to investigate the value of reliability:

1. The "portfolio theory approach," as developed initially for managing financial assets, provides a framework for comparing water supply options using a reliability-based cost adjustment for attaining a given reliability target
2. The WTP approach (the focus of this research) uses economic valuation techniques to directly estimate the values (i.e., WTP) for reliability held by water utility customers

The following sections briefly describe each approach, highlighting the differences between WTP estimates (such as derived from this research) and portfolio theory, as applied to water supply reliability.

### A.1.1 Portfolio Theory

Portfolio theory offers water supply managers with a sound conceptual basis and statistical approach for revealing the added value that can be attributed to reliability enhancement projects. The portfolio approach is used to adjust the costs of alternative water supply options to account for differences in reliability relative to a given reliability target for the portfolio (e.g., to deliver a given targeted quantity of water with 95% confidence, year to year).

Originally developed for application in financial markets, portfolio theory provides some useful insights into how water supply planners might develop and manage the portfolio of water sources available to them. The central premise, long recognized and applied by financial managers, is to jointly maximize expected returns (water yields) and concurrently also reducing the overall variance (fluctuations in yields across years or seasons) in portfolio returns. This can be accomplished by minimizing the covariance in yield risks across the assets held in a portfolio (Markowitz, 1952).

In essence, portfolio theory is a statistics-based formalized embodiment of the old maxim about not placing all of one's e.g.gs in one basket. The basic premise of portfolio theory applies to water resources planning. Each water supply option can be viewed as an asset that is subject to some sources and degree of risk (where risk refers to variability or uncertainty about the water yield, cost, or both). There may well be a premium value that a risk-averse community would be willing to pay to better manage its water risks, either by providing some insurance and/or by providing some variance-balancing water portfolio diversification. The portfolio approach, as applied to water supply planning, introduces the unique risk/benefit profiles of different water supplies to the analysis, thus allowing an assessment of increased (or at least equal-to-existing) supply reliability at the least cost, rather than merely the least-cost total supply irrespective of reliability and community values.

As with financial assets, sources and levels of risk vary across different types of water assets. In many traditional surface water sources, a key source of yield risk is the weather and its impact on local hydrologic conditions (e.g., droughts that leave stream flows or reservoirs too low to support desired levels of water extraction). Other sources of risk for traditional surface and groundwater sources include contamination (e.g., pollutant spills), over-extraction by other users (e.g., externalities arising where water is a common property resource), new institutional constraints (e.g., minimum instream flow requirements to account for ecosystem needs, or regulatory limits on groundwater extraction to prevent subsidence), and so forth. Cost risks (or, more suitably, "net revenue" risks) may be associated with increased pumping and treatment costs, as may arise with declining aquifer levels, deteriorating raw water quality, added regulatory requirements, and other factors. Net revenue risks also can be linked to declines in revenue collections (as when drought restrictions curtail water use and sales, and revenues decline below total annualized costs because volume-based water pricing rates remain fixed).

A more in-depth discussion of portfolio theory is provided in Kasower et al. (2007) and Wolff (2007). These papers also offer simple empirical illustrations of how much added value may be derived from having a water supply option with a yield variability that is uncorrelated (or negatively correlated) with the variability of other source water options in the community's water supply portfolio. This added value can also be used to develop a "constant reliability-adjusted cost" per unit of water delivered, which can then be used to develop a reliability-adjusted, cost-effectiveness comparison of water supply options.

### A.1.2 WTP Approach

The portfolio theory offers water supply managers a sound conceptual basis and a statistical approach for revealing the added value (benefit) of reliability enhancement projects. However, the portfolio approach does not provide a direct empirical examination of how much "value" people place on added reliability (e.g., the WTP to have a higher level of reliability for the community supply, such as increasing the probability of meeting a target total portfolio yield from 95% to 99%).

Estimating the WTP for changes in the reliability of water supply involves analytic techniques to elicit the values people place on reliability. Estimation procedures used to value changes in reliability for residential water users are generally based on one of two different approaches: "stated preference" and "revealed preference." Stated preference methods determine estimates for reliability based on the analysis of household responses to hypothetical choices posed in surveys. Revealed preference methods infer the value of reliability from data obtained from choices and decisions made in the marketplace (e.g., expenditures made to obtain higher levels of reliability or to avert potential shortages sometimes can be used to infer the value of reliability).

Another method for quantifying the value of reliability attempts to infer values from available cost and price data. Although cost does not necessarily equate to value, the cost that a city incurs for increased storage to improve reliability can be used as a proxy for the value of a reliable water supply. Additionally, avoided costs due to higher levels of reliability sometimes can be used to infer the value of reliability.

In recent years, economic and mathematical modeling techniques have also been developed to derive WTP estimates based on available data. These models have been used to estimate household WTP for changes in a combination of probabilistic water supply reliability and the retail price of water (see Lund, 1995; Jenkins and Lund, 2000; Alcubilla and Lund, 2006). An advantage of these models is the capability to examine a complete shortage probability distribution (not just specified events) and the ability to account for price effects (i.e., where higher water rates increase incentives for conservation and reduce the impact of shortages). Although this approach provides useful insights into WTP to avoid a range of shortages, it has only been used to evaluate hypothetical scenarios and has not been applied based on real-world data.

## A.2 Review of Existing Literature

The following sections overview stated preference, revealed preference, and cost-based studies related to how residential water users value the reliability of their water supply (i.e., WTP).[1] Given the nature of our research (using stated preference techniques to elicit WTP for improved reliability), we focus primarily on stated preference studies that examine the value of water supply reliability to residential customers.

1. The numbers reported later have all been adjusted based on the CPI to reflect mid-2009 US$ values.

### A.2.1 Stated Preference Studies

Stated preference methods rely on survey questions that ask individuals to make a choice, describe a behavior, or state directly what they would be willing to pay for specified changes in reliability. The most widely used stated preference technique has been the contingent valuation method, where respondents are presented with information about water quality and relationships between water quality and usability of the resource. Respondents are then asked to state or indicate to the researcher how much a given change in water supply reliability would be worth to them.

More recently, choice experiments are a stated preference approach that has begun to be used more extensively to estimate WTP. Choice experiments are a survey-based technique in which consumers are presented with two or more options for a good or service and are asked to state which option he or she prefers. By examining consumer preferences for the attributes and prices associated with their preferred option, WTP is inferred.

As detailed in the following sections, values for reliability are typically defined by stated preference studies as WTP to avoid a particular shortfall event. Water supply shortfall events are usually defined in different ways across studies. Factors used to describe a shortfall event include the percent of water available compared to the amount fully demanded (the shortfall amount), the frequency with which this condition may occur (e.g., 1 in 10 years), and the probability of a single event. In other studies, respondents are questioned on their WTP to reduce the probability of an event, not avoid it. A few more recent studies have elicited WTP to avoid impacts associated with shortages (e.g., watering restrictions).

In 1987, Carson and Mitchell conducted the first formal stated preference study related to water supply reliability. This study, conducted for the MWD, used contingent valuation method techniques to evaluate how residents in southern and northern CA value reliability. The authors used a discrete choice referendum survey format to estimate household WTP to avoid water shortages of a given magnitude and frequency. Specifically, respondents were asked whether they would vote yes or no on a referendum that would alleviate the threat of a specific water shortage scenario, given a specified (annual) cost to their household if the referendum were to pass. Median annual household WTP was determined for four reduction scenarios, based on a magnitude of reduction ranging from 10% to 35%.

The authors used their estimates for individual household WTP to determine aggregate annual WTP by households within the State Water Project (SWP) service area. Based on 1983 census data, there were approximately 5.5 million households within the SWP district at the time of the survey.

Table A.1 presents the results of the 1987 Carson and Mitchell study. WTP estimates have been adjusted to reflect mid-2009 dollar values.

Carson and Mitchell made significant attempts to ensure that the results of the study represent lower bound estimates for WTP. First, the study defines the value of water reliability in terms of WTP rather than WTA. Studies have shown that WTA is typically 2 to 6 times larger than WTP for public goods for which there are no substitutes (Carson and Mitchell, 1987). Second, the study's WTP estimates are based on median values rather than on mean values. The authors note that mean WTP is usually used in economic valuation and mean WTP values are typically 1.5 to 4 times larger than median WTP (Carson and Mitchell, 1987).

**Table A.1. Annual Median Household WTP to Avoid Water Shortages under Four Scenarios (mid-2009 US$) (baseline = household's current consumption of water)**

| Scenario | Description of Scenario | Household Annual Median WTP | Annual Aggregate Value of Supply Reliability (millions) |
|---|---|---|---|
| A | A 30–35% reductions from the baseline once every five years | $218.04 | $1204 |
| B[a] | A 10–15% reduction from baseline once every five years | $158.25 | $880 |
| C | A 30–35% reduction from baseline in two out of five years | $493.51 | $2673 |
| D | A 10–15% reduction from baseline in two out of every five years | $290.72 | $1606 |

Source: Based on data from Carson and Mitchell (1987).

[a]The results for Scenario B were given using a 95% confidence interval ($765 million to $994 million). The mid-point of the confidence interval is reported in the table.

Third, those respondents that refused to participate in the survey or responded "don't know," are treated as households who are truly not willing to pay the specified amount. Therefore, they are treated as respondents willing to pay $0 and are not discarded from the sample (Carson and Mitchell, 1987).

Though the authors attempt to be sound in their methodology, there are some inherent problems with the study. First, as noted previously, the study uses a referendum format, which has been shown to produce inconsistent (unreliable) estimates and to overstate WTP (McFadden 1994; Jenkins et al., 2003). Second, the "single-bounded" discrete choice format used in the study involves asking the respondent only one referendum style question: whether or not he or she would be willing to pay a specified dollar amount to avoid a water shortage of a given magnitude and frequency. However, Hanemann et al. (1991) show that a variation of this approach, the "double-bounded" discrete choice format (described later), is asymptotically more efficient than the conventional single-bounded method (Koss and Khawaja, 2001).

Finally, the survey allows for the prevention of a water shortage rather than a reduction in likelihood or severity. However, the elimination of shortfalls is not a realistic scenario, indicating that the study's WTP values should be interpreted as upper bound estimates (Griffin and Mjelde, 2000). [It should be noted, however, that Griffin and Mjelde used an improved survey design that did not allow for the complete avoidance of shortages, and still obtained inconsistent WTP values (see following text).]

In 1993, CUWA hired Barakat and Chamberlin, Inc. to conduct a second stated preference study related to reliability.[2] The objective of this study was to measure WTP among water users in 10 CA water districts to avoid shortages of varying magnitude and frequency.

2. This study was republished by its authors in a peer-reviewed journal in 2001: Koss and Khawaja (2001).

The authors used a referendum style, double-bounded dichotomous choice survey to estimate household WTP. With the double-bounded dichotomous choice model, respondents are engaged in two rounds of questioning. If the respondent answers yes to the initial question—”Are you willing to pay $X (a specified bid amount) for the referendum just described?”—then the follow-up question asks the respondent if they would be willing to pay a higher specified amount. Alternatively, if the response to the initial question is no, then the follow-up question uses a lower value. As a result, the researcher can place each respondent in one of four categories: “yes/yes,” “yes/no,” “no/yes,” or “no/no,” all of which correspond to smaller, more informative intervals around each respondent (Koss and Khawaja, 2001). As noted earlier, studies have shown that a double-bounded dichotomous choice format is asymptotically more efficient than the single-bounded approach used by Carson and Mitchell (1987).

As shown in Table A.2, the magnitude of the water shortage scenarios used in the survey ranged from 10% to 50%, with frequencies ranging from once every 3 years to once every 30 years. Bid amounts ranged from $1 to $50 (1994 US$), in increases to the respondent’s monthly water bill.

The study found that mean WTP varied across the counties included in the study, ranging from a low of $16.91/month ($203/year) to avoid a 20% shortage once every 30 years to a high of $24.63/month ($296/year) to avoid a 50% shortage once every 20 years. These results are relatively similar to those from the Carson and Mitchell (1987) study.

These WTP results were not used to calculate the annual aggregate value of providing water reliability, nor is there any indication of the total number of users served by CUWA members. However, the study does indicate that additional customer payments would total more than $1 billion per year (CUWA, 1994; 1994 US$) when aggregating across all consumers in the state. Additional key findings include:

- WTP increases with increasing magnitude and frequency of shortages
- Respondents were willing to pay to even avoid minor shortage scenarios
- Users may make a greater distinction between “shortage” and “no shortage” than between magnitude and frequency
- Shortage magnitude is a more important determinant of WTP than shortage frequency
- Individuals who indicated a desire for their community to grow have a higher WTP than those who wish that their communities stay the same size or get smaller
- Those respondents who considered water to be a long-term problem in the area have a higher WTP than those who did not

The survey was designed and executed well, and the study is cited several times in water reliability literature. However, similar to Carson and Mitchell (1987), a shortfall in the design of the survey was their use of WTP to “avoid” a shortage, rather than to reduce the likelihood or severity. Barakat and Chamberlin’s findings should therefore be interpreted as upper bounds on household WTP (Griffin and Mjelde, 2000). Furthermore, again like Carson and Mitchell (1987), the survey asks questions in a referendum format, which has been shown to produce unreliable and overestimated values (McFadden, 1994; Jenkins et al., 2003).

**Table A.2. Mean Monthly WTP to Avoid Water Shortages of Varying Magnitude and Frequency (mid-2009 US$) [from detailed model, Barakat and Chamberlin (CUWA, 1994)]**

| Shortage (% reduction from full service) | Frequency (occurrences/years) | | | | |
|---|---|---|---|---|---|
| | **1/30** | **1/20** | **1/10** | **1/5** | **1/3** |
| 10 | | | $16.93 | $17.44 | $17.64 |
| 20 | $16.91 | $17.95 | $19.01 | | |
| 30 | $18.99 | $20.08 | $21.21 | | |
| 40 | $21.19 | $22.33 | $23.48 | | |
| 50 | $23.46 | $24.63 | | | |

Results of the study also show a high "threshold effect" and declining marginal WTP related to the extent and duration of shortage (Wade and Roach, 2003). For example, the authors report a monthly WTP to avoid a 10% shortage once in 10 years of about $17, whereas the WTP to avoid a 40% shortage is only about $23. This threshold effect can be explained by a common finding in contingent value studies known as embedding. Embedding describes the situation when "the value placed on a resource is virtually independent of the scale of the resource" (McFadden, 1994). Wade and Roach (2003) report that the declining marginal loss curve led this study to be rejected in CA policy applications because of people's observed rising penalty costs to use water in droughts.

In an attempt to improve upon the methodology used in previous studies, Griffin and Mjelde (2000) used stated preference techniques to value water supply reliability among households in seven TX cities. The primary objective of this study was to investigate the value of *current* water supply shortfalls (i.e., existing shortages of known strength and duration). The authors also attempted to determine the value of *future* shortfalls (i.e., probabilistic shortages of differing strength duration and frequency).

The survey used in the study included two contingent valuation questions:

1. A closed-ended WTP question that described a current supply shortfall of X% of the community's water demand for a duration of Y summer days. The respondents were asked if they would be willing to pay a one-time fee of $Z to be exempt from the outdoor water restrictions.
2. An opened-ended WTP or WTA question concerning a hypothetical increase or decrease in future water reliability. For this question, an initial situation was posed to the respondents in which approximately once every U years a shortfall of V% would occur for a duration of W days. Depending on the survey, the question then posed a potential improvement in one of the parameters, and the others stayed constant. This question design was intended to be an improvement on the "avoided shortage" problem in the Carson and Mitchell (1987) and the CUWA (1994) studies.

For WTP to avoid a current water supply shortfall, respondent WTP decreased as the fee (to avoid water use restrictions) increased. Further, respondents were found to be more likely to pay to avoid restrictions as the duration and/or strength of the restrictions increases. Income was also found to positively influence WTP. In addition, respondents who live at the survey residence (as opposed to landlords who do not) are more likely to be willing to pay for reliability improvements.

For the future shortfall scenario, individual income levels were also found to positively influence WTP. Respondents in cities with a higher average rainfall were found to be willing to pay less than respondents in drier cities. In contrast to the value of a current shortfall, individual characteristics appear to help explain WTP bid levels. For example, as the number of people living at a residence increases, the respondent is willing to pay more for reliability enhancement. In addition, respondents who have experienced water shortfalls in the last five years are, on average, willing to pay less for the reliability increase than those who have not experienced a shortfall.

As shown in Table A.3, the average respondent was willing to pay $37.40 to avoid a three-week current shortfall of 20%. A one-week increase/decrease in shortfall duration increases/decreases this value by $3.00. Every 10% increase or decrease in shortfall strength increases or decreases this value by $2.65. In addition, as duration increases, respondents are likely to pay more to avoid restrictions (i.e., the value of reliability increases with duration of the shortage).

For the future shortfall scenario, WTP and WTA measures were obtained as means from the survey responses as well as calculated from the economic model developed as part of the study. As noted previously, the WTP to modify future shortfalls was determined based on an increase in the respondent's monthly water bill (reported as follows in annual values in 2009 US$):

- Mean WTP and WTA per respondent are $128/year and $191/year, respectively
- The mean model-predicted WTP and WTA per respondent are $147/year and $199/year, respectively

**Table A.3. Respondents' WTP to Avoid Water Restrictions from a Single Current Shortfall Event (mid-2009 US$[a])**

| | Shortfall Duration | | |
|---|---|---|---|
| **Shortfall Strength** | **14 Days** | **21 Days** | **28 Days** |
| 10% | $31.74 | $34.76 | $37.77 |
| 20% | $34.40 | $37.40 | $40.42 |
| 30% | $37.05 | $40.06 | $43.08 |

Source: Griffin and Mjelde (2000).

[a]Dollars adjusted from 2000 value to mid-June 2009 US$ based on CPI.

As noted previously, the authors used an open-ended question format to evaluate future shortfall scenarios to improve upon the methodology used in previous studies. However, the future shortfall values appear to be inconsistent with the reported current shortfall values. When the current shortfall values are used to calculate the future shortfall values, the calculated values are much lower than the WTP and WTA from the survey results. The authors believe that the future shortfall valuation is the source of the discrepancy because the current shortfall scenario was easily understood by respondents and is a common line of questioning for contingent valuation surveys. On the other hand, respondents did not appear to understand the future shortfall query. The authors concluded that using frequency to convey probability might have confused the respondents. Therefore, although the study may have been an improvement in design from previous studies, the results are inconsistent and somewhat overstated for small changes in future probability shortages (Jenkins et al., 2003).

In 1994, Howe and Smith used contingent valuation to measure customers' WTP for improved reliability (and WTA reduced reliability) in three Colorado towns: Boulder, Aurora, and Longmont. For this study, respondents were asked to consider hypothetical changes in their city's level of reliability (increases and decreases in frequency of a specific shortage event), and to assert whether or not these changes would be acceptable if accompanied by appropriate (but unspecified) changes in their water bills. The questions were set up in a "yes" or "no" format. For "yes" responses, quantitative WTP and WTA values were elicited from the respondents for two increased reliability scenarios (WTP) and two decreased reliability scenarios (WTA).

The type of water shortage investigated in the study was defined by the authors as a "standard annual shortage event": a "drought of sufficient severity and duration that residential outdoor water use would be restricted to three hours every third day for the months of July, August, and September" (Howe and Smith, 1994). The base probabilities of the SASE occurring for each city were 1/300 for Boulder, 1/10 for Aurora, and 1/7 for Longmont.

The authors compared the study's WTP and WTA estimates to the costs or savings associated with investments in increased supply or reductions in reliability (e.g., savings associated with selling water rights). This comparison was used to determine whether an increase or reduction in reliability would be justified. Key findings from the study include:

- In general, as expected, larger WTA amounts are required for greater decreases in reliability and larger WTP amounts are offered for greater increases in reliability.
- Household WTA compensation for a decrease in reliability under the first WTA scenario (0.7% to 11%, depending on the city) ranged from $80/year in Boulder to a high of $195/year in Longmont. WTA compensation for a decrease in reliability under the second scenario (1.7% to 40%, depending on the city) ranged from $95/year in Boulder to $281/year in Longmont. In Boulder, under both scenarios, this would be enough to justify a reduction in the reliability of supply.
- In Aurora and Longmont, the two towns with lower levels of reliability, consumers were not willing to pay enough to cover the cost of investment necessary to improve reliability. In Boulder, a town with very reliable water supplies, consumers were willing to pay even less for improved reliability, and no increase in reliability was justified.
- For the WTP scenarios, two sets of averages were developed. The first average is based only on "yes" answers to the accompanying WTP. For the second average,

"no" responses were counted as a WTP of $0 and incorporated into the overall average.

- WTP for the first scenario (increase in reliability in a range of approximately 0.16% to 9.2%, depending on the city) ranged from $82/year in Boulder to $106/year in Longmont. The WTP, including "no" respondents, ranged from $19/year in Boulder to $33/year in Aurora.
- The WTP for the second scenario (increase in reliability in a range of approximately 0.23% to 12.2%, depending on the city) ranged from $75/year in Boulder to $140/year in Longmont. The WTP, including "no" respondents, ranged from $18/year in Boulder to $34/year in Aurora.

When compared to the results of the other contingent valuation surveys, the results of this study are lower. This is likely due to differences in survey design and methodology. As noted previously, Carson and Mitchell (1987) and CUWA (1994) both asked respondents their WTP for complete avoidance of a shortfall with a given percentage. Griffin and Mjelde (2000) questioned respondents on their WTP to reduce the probability of a potential shortfall. All three of these studies determined what people were willing to pay to maintain their current well-being. However, Howe and Smith (1994) determined respondents' WTP for a percentage increase in reliability. The lower values of their study may be attributable to the fact that respondents were already content with their current level of reliability. People may be more willing to pay for maintaining a level of service they currently have than for a potential improvement in that service.

Although Howe and Smith's study is also widely cited in the water supply reliability literature, it should be noted that the study's emphasis on a single type of shortage, the SASE, limits the transferability of the results (Griffin and Mjelde, 2000). More severe or moderate events are not considered in the authors' calculations of the WTP and WTA.

Two recent studies conducted in Australia (Hensher et al., 2006; Tapsuwan et al., 2007) used choice experiment survey formats to examine household preferences for water supply reliability in terms of WTP to avoid drought restrictions. Choice experiments are a survey-based technique used to model consumer preferences for goods or services defined by certain attributes. In the survey, consumers are presented with two or more options for goods or service levels (with different levels of attributes) and asked to state which option he or she prefers. By including price as one of the attributes, WTP for a specific attribute can be indirectly recovered from people's choices (Hanley et al., 2001, as cited in Tapsuwan et al., 2007).

Tapsuwan et al. (2007) used a choice experiment survey to estimate household WTP in Perth, Australia, for different source development options and for avoiding outdoor water restrictions. The authors chose to use choice experiments because it allowed for "flexible alternatives and generated considerable cost savings through the ability to value a number of options simultaneously" (Tapsuwan et al., 2007). To measure consumer preferences, the authors developed a choice experiment survey that included the following attributes:

- Measures of regular outdoor restrictions
- Probability and severity (duration) of a complete sprinkler ban
- Sources of alternative water supplies
- Cost to the household (as an increase in annual household water bill)

Each questionnaire presented three options, including a status quo option (doing nothing about future supplies), which remained the same across all choice sets. Under this option, households would be restricted to watering one day per week (a level five sprinkler restriction) for the entire 10-year period being considered. They would also face a one-in-three year chance of a total sprinkler ban. Household water bills would remain the same.

The authors found that households consider water bill level, the supply source, and the ability to water three days a week as important factors affecting household WTP for a particular option. One of the most interesting findings of the study was the lack of significance of any variable relating to the probability or severity of a complete sprinkler ban. The authors believe that this may be because respondents felt that the development of new sources would override these outcomes. Households do show a preference for increasing sprinkler days from one day a week (under the status quo option) to three days a week, which indicates that respondents value access to sprinkler use, and therefore must have some concern over complete sprinkler bans (Tapsuwan et al., 2007).

For the option of moving from one day to three days of sprinkler use, the authors found consumers are willing to pay 22% extra on their annual water bill (around $54[3] based on average bills of respondents of $246). This was the only statistically significant variable in the economic model developed based on the choice experiment surveys.

Another interesting finding of the study is the equivalence of the status quo option (sprinkler use one day per week) and the option allowing sprinkler use five days per week. As the five-day use includes the possibility of using sprinklers on three days, one might expect that the option to move to five days would be valued as much as the option to move to three days. A possible interpretation of this finding is that respondents place a value on responsible water use (i.e., respondents might be attaching a social unacceptance to the use of sprinklers five days per week) (Tapsuwan et al., 2007).

Overall, the study found it was difficult to identify preferences to pay for the reduced risk of water restrictions in either the short or long term. The authors conclude that respondents may have found the attributes presented in the choice set format too difficult to understand, particularly because it involved an assessment of the risk of an event that may have been difficult to grasp. Alternatively, the source development options included as attributes may have introduced a labeling bias into the questionnaire. If source development was seen as an overriding factor and respondents ignored associated levels of reliability presented in each choice set, some modifications to the survey instrument would be required in the future in order to assess the value of reliability.

Hensher et al. (2006) used choice experiments to evaluate consumer preferences for avoiding drought restrictions in Canberra, Australia. For this study, the authors presented respondents with a series of six choice experiments covering restrictions on the use of water. Each experiment described two restriction scenarios and respondents were asked which of the two options they preferred. The range of attributes and levels that comprised each of the options in the choice experiments were:

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3. Adjusted to 2008 US$ from original study value of $57 AU$, using Australian to U.S. exchange rate of $0.90938.

- Frequency and duration of the restriction
- Days the water restrictions apply (every day, on alternate days, and no restrictions)
- Level of water restriction, based on Canberra's current drought policy (levels ranged from "no restriction" to "Stage 5 restriction," where all outdoor water use is banned)
- Price, expressed as "total water and sewerage bill for the year"
- Appearance of urban landscape including public lawns, parks, and spaces (levels of this attribute included "some brown lawns and no lush green lawns" and "lush green lawns")

The respondent's choice between the two options in each experiment was modeled with a standard binary logit model (McFadden, 1974). The authors found evidence that customers are unwilling to pay (i.e., a WTP that is not statistically different from zero) to avoid most types of drought-induced restrictions. More specifically:

- Respondents appear unwilling to pay to avoid any low-level restrictions (Stage 1 or 2 level restrictions, as defined in the survey)
- Respondents also appear unwilling to pay to avoid higher levels of restrictions (Stage 3 or higher) that are not in place every day and all year
- Given the option of watering on alternative days, customers appear willing to adjust their watering schedules compared to paying higher water bills
- Customers appear willing to tolerate high-level restrictions for limited periods each year (up to all summer), compared to paying higher water bills
- Customers display an unwillingness to pay to avoid brown lawns in public areas

To estimate WTP, the variables included in the model were differentiated into two variables based on the findings noted previously: "frequency of restrictions that matter," defined as those that apply every day, last all year, and are Stage 3 or higher; and "frequency of restrictions that don't matter," which are all other restrictions. The "restrictions that don't matter" include those types of restrictions found to be insignificant in the (binary logit) model developed based on survey results.

Model results indicate that respondents are willing to pay 31.26% of their water bill, or $232[4] on average, for a one unit reduction in the frequency of restrictions "that matter." Note that because restrictions that matter last all year, a frequency of 1 (once a year) means that restrictions apply continuously, all year, every year. Similarly, a frequency of 0 means that there is virtually no chance that restrictions will be imposed. Thus, $232 is the amount that householders are willing to pay annually, on average, to move from a situation with continuous restrictions at Stage 3 or above every day, all year, every year, to a situation with virtually no chance of restrictions.

The authors used the model results to calculate the amount customers are willing to pay to reduce the frequency of restrictions that matter under various scenarios. For example, WTP to reduce these restrictions from, say, once every 10 years to once every 20 years was calculated as $11.60 per household, annually, on average (one-twentieth of $232—because the situation

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4. Adjusted to 2008 US$ from the original study value of $239 AU$ using the Australian to U.S. exchange rate of $0.90938. This assumes original study reported results in 2006 US$. Actual study/survey was conducted in 2003 so this is a conservative estimate.

reflects a reduction in frequency of restrictions by one-twentieth). Similarly, the amount householders would be willing to pay to reduce the frequency of restrictions that matter from once every 20 years to once every 30 years is estimated to be $3.87 on average (one-sixtieth of $232) per year.

Several points are important to consider when interpreting the results of this analysis. First, the choice experiment used in the survey included only three options for the length of restriction: one month, all summer, and all year. Interpolation of the results to other lengths is a matter of interpretation beyond the actual data obtained in the study. Second, in the experiments, the length of the restrictions is stated to the respondent, such that the respondent knows how long the restrictions would last when evaluating them. In practice, water restrictions have been, and probably will be in the future, imposed without a specified ending date. That is, the length of the restriction is not known beforehand, but only after the restrictions have been lifted. It is possible that customers react differently to restrictions whose length is not known beforehand than to restrictions of a known length.

### A.2.2 Summary of Stated Preference Study Results

Table A.4 summarizes annual WTP for reliability improvements based on the studies highlighted previously. With the exception of households in Canberra, Australia (Hensher et al., 2006), it appears that most households are willing to pay in excess of $100 annually for reliability improvements.

Overall, whereas the stated preference studies discussed earlier are valuable in terms of gaining insight into the value of reliability, none are perfect in their methodology. In addition, it is somewhat difficult to interpret how to apply the results of these studies to value reliability in the context of 2009. The survey methods used in most of these studies to develop the data, as well as the statistical approaches used to analyze these data, have improved in the years since the studies were implemented.

Although stated preference approaches have been applied to the valuation of nonmarket goods for many years, the method has limitations that need to be acknowledged and considered. For example, Griffin and Mjelde (2000) note that one difficulty with stated preference studies for water reliability is the notion of the "birthright" perspective. It is not uncommon for respondents to view water as an inalienable right. Consequently, whereas they highly value water reliability, the notion that water should be free can lead to a reduction in the respondents' stated WTP for reliability. If the limitations are acknowledged and efforts are made to perform the studies in an appropriate manner, stated preference studies can yield informative results.

Finally, in addition to the studies highlighted earlier, a handful of stated preference studies have also been conducted in relation to WTP to avoid temporary disruption in supply (lasting a few hours to a few days) due to infrastructure failure and/or repair (see MacDonald et al., 2003; Damodaran et al., 2004; Hensher et al., 2005; Brozovi´c et al., 2007). These studies are more related to the reliability of infrastructure rather than the overall reliability of supply and are therefore not highlighted here.

**Table A.4. Summary Table of Results from Stated Preference Studies (2009 US$)**

| Source | Shortfall Amount | Frequency | Probability | Annual WTP/ Household |
|---|---|---|---|---|
| Carson and Mitchell (1987) | 10% to 15 % | 1 in 5 years | 20% | $158 |
| Carson and Mitchell (1987) | 10% to 15 % | 2 in 5 years | 10% | $291 |
| CUWA (1994) | 20% | 1 in 30 years | 3.3% | $168 |
| Carson and Mitchell (1987) | 30% to 35% | 1 in 5 years | 20% | $218 |
| Carson and Mitchell (1987) | 30% to 35% | 2 in 5 years | 10% | $494 |
| CUWA (1994) | 50% | 1 in 10 years | 5% | $297 |
| Griffin and Mjelde (2000) | na | Na | na | $128 |
| Griffin and Mjelde (2000) | na | Na | na | $147 |
| Howe and Smith (1994)[a] | 0.16% to 9.2%[b] | Na | na | $94[c] |
| Howe and Smith (1994) | 0.23% to 12.2%[d] | Na | na | $108[e] |
| Hensher et al. (2006) | na | Na | na | $232[f] |
| Tapsuwan et al. (2007) | na | Na | na | $54[g] |

na = not applicable.

[a]Howe and Smith (1994) also estimated WTA values for decreases in reliability. Annual WTA results per household for approximately a 0.7% to 11% decrease in reliability, depending on the city, ranged from $80 to $195. Annual WTA results for approximately a 1.7% to 40% decrease in reliability, depending on the city, ranged from $95 to $281.

[b]This percentage range does not represent the magnitude of the shortfall, as is the case in the other studies. This range represents increased probability over the base probabilities of the SASE. The actual percentage increase is dependent on the city. The associated dollar values are the annual WTP per respondent for an increase over their current reliability. If "no" respondents for this increased probability range are included into the dataset (respondents' WTP = $0), the WTP range is from $19/year to $33/year per respondent.

[c]Value represents the average of the WTP range given in the study ($82 to $106 per year per respondent).

[d]See table note c. If "no" respondents for this increased probability range are included into the dataset, the WTP range is from $15/year to $29/year per respondent.

[e]Value represents the average of the WTP range given in the study ($75 to $140 per year per respondent).

[f]This is the average amount that householders are willing to pay to move from a situation with continuous restrictions at Stage 3 or above all year every year, to a situation with virtually no chance of restrictions.

[g]This is the annual amount householders are willing to pay for the option of moving from one day to three days of sprinkler use.

### A.2.3 Revealed Preference and Cost-Based Studies

A few studies have used the revealed preference and cost-based methods to determine values for water supply reliability. Fisher et al. (1995) explored how price can be used as a tool to reduce demand during a drought. Using a range of estimated price elasticities for residential customers (from selected studies), the authors calculated the loss of consumer surplus associated with a price-induced 25% reduction in consumption in the East Bay Municipal Utility District (CA) service area. With varying demand elasticities, welfare losses were estimated within a range of $60 to $270 per acre-foot. This loss in consumer surplus is equated to WTP for improved reliability.

In 2002, the California Recycled Water Task Force was established to investigate specific recycled water issues. The economic group of the task force was charged with identifying economic impediments to enhancing water recycling statewide. The resulting report uses a case study of GWRS in Orange County as an illustration for the importance of economic feasibility analysis. The GWRS was designed to recycle an estimated 70,000 acre-feet per year of effluent and inject it into the Orange County Aquifer. According to the Groundwater Replenishment System Financial Study (Public Resources Advisory Group, 2001), the value of drought proofing (the value of reliability), based on drought penalties and rate increases for consumers, ranged from $210 to $300 acre-feet per year ($9.1–$15.6 million a year for 40 years with a total present value of $272 million at a 5.5% discount rate) (Recycled Water Task Force, 2002).

In a similar investigation in 1997, NRC estimated that if Orange County were to lose its reliable groundwater supply to saltwater intrusion, the cost of securing water by retail producers would jump from the 1997 cost of $106 million to $210 million. The $104 million increase arises because the water once pumped from the aquifer would now have to be purchased from MWD at the non-interruptible rate (NRC, 1997). The sharp increase in cost charged by MWD for non-interruptible water supplies highlights the fact that reliability has a key role in water pricing (Paul, 2004) (i.e., as actual or potential shortages worsen and demand outpaces supply, users are willing to pay more for water).

As mentioned earlier, although the cost of a water project does not necessarily equal the value of the project or program, cost sometimes can be used as a lower bound proxy estimate of the value attached to increased reliability. Varga (1991) investigated the role of local projects and programs in the City of San Diego to enhance imported water supply and improve reliability. The MWD provides water to San Diego from the Colorado River and northern CA, based on availability. To encourage the use of existing local reservoir capacities and improve the reliability and yield of the imported water system, MWD and CA introduced water rate credits for serviced cities. The first program instituted was the Interruptible Credit Program. An interruptible credit applies to water that either could be reduced or have its delivery interrupted by the MWD or another external agency. In 1991, the interruptible credit rate was approximately $70 per acre-foot. The second program is the Seasonal Storage Credit Program. This program encourages water agencies to use available local storage to increase the capacity and yield of the imported water system. The 1991 seasonal storage rate was approximately $130 per acre-foot. MWD is paying for direct increases in reliability and, therefore, the credit rates can be used as the value for an acre-foot increase in water supply reliability.

Thomas and Rodrigo (1996) measured the benefits of nontraditional water resource investments. The focus of the study was again on MWD and its member agencies. They investigated the benefits of developing additional resources in the region through several alternatives, including increased imported supplies (base case), conjunctive storage of local groundwater basins, and recycled water and groundwater recovery projects (preferred case). To determine the value of the preferred case, the savings attributable to each of these resources were compared to the yield associated with the resource. Thomas and Rodrigo (1996) note that "dividing the total present value of benefits by the expected groundwater replenishment deliveries (e.g., the difference between the base case and the preferred case and the groundwater case for conjunctive use storage), yields a dollar/AF index." In the case of conjunctive use storage, the modeling revealed that carryover or drought storage, which helps ensure greater reliability during dry periods, provides a benefit of approximately $414 per acre-foot to the region.

In 2003, Wade and Roach investigated the reduction in NED Benefits if water supplies to metro Atlanta were capped at 2000 water withdrawal levels and no new supply alternatives existed. This analysis estimated shortage costs including costs of shortage management (conservation and reclamation); agency revenues lost from reduced water sales; lost consumer surplus; and economic losses to the region. The water and wastewater NED Benefits were summed to determine total shortage losses through 2050 (present value at year 2000 using a federal discount rate of 6.625%). The present value NED Benefits loss associated with a cap on supplies was estimated to be more than $23.9 billion. Total losses at 10-year intervals were converted to costs per acre-foot based on the total shortage amounts. Water and wastewater losses were found to range from $3908 per acre-foot for a 17% shortage to $27,380 per acre-foot for a 47% shortage, over the 40-year period from 2010 to 2050.

An overview of the value of reliability inferred from results of revealed preference and cost-based approaches is provided in Table A.5. When compared on a dollar per acre-foot basis, these results are considerably lower than those based on WTP from the stated preference studies highlighted previously. This reflects the fact that stated preference results are designed to reflect the real *value* (i.e., WTP) of water supply reliability, whereas *cost*-differential based results are simply reflective of agency pricing decisions that are not likely to reflect value (WTP) considerations.

**Table A.5. Water Supply Reliability Values Inferred from Revealed Preference or Cost and Price Differential Results (mid-2011 US$)[a]**

| Source | Value ($ per acre-foot) | Basis |
|---|---|---|
| Fisher et al. (1995) | $63 to $283 | Welfare loss per acre-foot due to a price-induced reduction in water consumption of 25% |
| Recycled Water Task Force (2002) | $220 to $314 | The value (acre-foot per year) of drought proofing based on drought penalties and rate increases for customer |
| NRC (1997) | $406 | The difference in cost of local groundwater supplies versus the MWD noninterruptible rate |
| Varga (1991) | $73 | The rate per acre-foot that MWD credits local water retailers to store imported water in local reservoir to increase reliability of imported supplies |
| Varga (1991) | $136 | The rate per acre-foot that MWD credits local water retailers to seasonally store imported water to increase capacity and yield of imported water system |
| Thomas and Rodrigo (1996) | $433 | The benefit per acre-foot of conjunctive use storage to ensure greater reliability |
| Wade and Roach (2003) | $4090 to $28,650[b] | Total present value losses associated with a 17% and 47% (cumulative through 2050) reduction in supply in metropolitan Atlanta |

[a]The numbers reported here have been adjusted based on the CPI to reflect mid-2011 US$ values.

[b]Present value over 40 years. In terms of annual values, this is equivalent to $294 to $2,056 per acre-foot per year.

*Appendix B*

# Long Beach Focus Group Materials

## B.1 Focus Group Recruitment Script, Long Beach Example

**CITY OF LONG BEACH FOCUS GROUPS**

**RECRUITMENT SCREENER: City of Long Beach, CA**

*Notes on recruitment, per agreement:*

*Wednesday, August 25, 2010, 5:30 p.m. and 8:00 p.m.*

- *Each night recruit:*
  - ***Education Distribution**: Participants should be roughly distributed across education categories based on U.S. Census distribution for the area.*
  - ***Age Distribution**: Participants should be roughly distributed across age categories based on U.S. Census distribution for the area.*
  - *Participants should NOT have participated in a focus group during the last 9 months.*

*Recruit per attached schedule.* ***Track the number of attempts, no contacts, refusals, and acceptances.***

**INTRO**. Hello, may I speak with **[Contact name]**? My name is **[caller's name]** and I am calling from **[name of firm]**. I'm calling to offer you $125 and invite you to participate in a two-hour research study we're doing of people's opinions on issues facing City of Long Beach area residents. I'm not selling anything, and would only like to ask you a few quick questions. *(If asked: 3-4 minutes).*

**B. Are you 20 years old or older?**

1. No, Less than 20 years of age ----------------> Continue to Q2
2. Yes, 20 or more years of age ---------> Continue to Q3

**Q1. Can I speak to someone in your household who is 20 years old or older?**

1. No -----------------------------> *Thank and TERMINATE*
2. Yes ----------------------------> Ask to have that person put on the phone

(GO BACK TO **INTRO**)

**We'll be holding a 2-hour group discussion on [fill in date]. To thank you for giving us your time, and we will give you $125 at the end of the discussion.**

*<< Did respondent self-terminate at this point?*

*1. No (continue)*

2. *Yes (end of data) >>>*

**Before I tell you more about the discussion, I'd like to ask you a few questions about yourself and your household. Answering these questions will take just a couple of minutes – all your answers will be kept confidential.**

*BACKGROUND, IF NEEDED IN RESPONSE TO QUESTIONS:*

*>> This is for research and is not sales or marketing related in any way.*

*>>We want to talk with people from a wide variety of backgrounds and experiences.*

**C. In what type of residence do you currently live? *[Would like 60% to be from 1 or 2 and 40% from 3, 4, 5, and 6]***

3. Single family home **[Skip to Q6]**
4. Mobile home with a private lot **[Skip to Q6]**
5. Mobile home with no private lot
6. Townhouse or condominium
7. Duplex, triplex, or fourplex
8. Larger apartment building (5 or more units)

**Q2. Is there a lawn or garden area shared by other residents?**

1. Yes **[Ask Q5 and skip Q6]**
2. No **[Skip to Q7]**

**Q3. About how large is the lawn or garden area shared by other residents?**

1. Small (less than 5,000 square feet)
2. Large (5,000 square feet or larger)

**Q4. About how large is your lot size?**

1. Small (less than 1,000 square feet)
2. Large (1,000 square feet or more)

**Q5. In what year were you born? (RECORD YEAR)**

______________________

**Q6. What is the highest level of education you have completed? (DO NOT READ LIST)**

1. 8 years or less of school
2. 9 to 12 years of school (high school)
3. Some college or technical school
4. Completed technical school or an associates degree program
5. Completed four year college degree
6. Some or completed graduate school work
7. REFUSED

**Q7. How comfortable do you feel reading in English?**

1. Completely comfortable
2. Very comfortable
3. Moderately comfortable
4. Slightly comfortable [*Do not terminate until interview complete then do not select]*
5. Not comfortable at all [*Do not terminate until interview complete then do not select]*

**Q8. RECORD RESPONDENT'S GENDER <*Need a mix*>**

1. Male
2. Female

**Q9. Do you, or does any member of your household, work for a market research firm**

1. Yes ----> *Do not terminate until interview complete*
2. No

**Q10. Have you participated in any group discussion for research during the last 9 months?**

1. No -------> Continue.
2. Yes -------> *Thank and TERMINATE*. "Thank you for your time, these interviews are open only to individuals who have not recently participated in a focus group or interviews at a survey center."

**Q11. As I mentioned earlier, our group discussion will be about people's opinions on issues facing City of Long Beach area residents. This will last about 2 hours, and we will pay you $125 for your time.**

The study will take place at [FILL IN NAME OF RESEARCH FACILITY]. The facility is located at [ADDRESS]. We are scheduling two groups; the first begins at 5:30 p.m., the second at 8 p.m. Which time would work best for you?

9. RESPONDENT REFUSED --> Thank and terminate.

Thank you. We will mail you a letter to remind you of the date, time, and location of the interview, and give you directions on how to get to the <*site*>.We will also give you a reminder call the day before the study. If you need glasses for reading, be sure to bring them with you. Also, we are not able to provide childcare during this time, so please make other arrangements if needed.

Since we are recruiting only a small number of people for these interviews, your participation is very important to us. If for some reason you cannot make this time, please call us at (XXX) XXX-XXXX and let us know so that we might find a replacement.

Name: ______________________________

Address: ______________________________

______________________________

______________________________

Phone Number: (XXX) XXX-XXXX

Thank you for agreeing to share your opinions!

If you have questions before the focus group meets, please call **[ENTER APPROPRIATE NAME FOR CONTACT PERSON]** at **[ENTER APPROPRIATE CONTACT PHONE NUMBER]**.

## B.2 Focus Group Moderator Script, Long Beach Example

**Focus Group Script**
**Long Beach Water Department**
**August 25, 2010**

### Materials

- Each participant will need a sharp pencil, and the moderator should have additional pencils if participants need them.
- Each participant should have a pad of paper in front of them.
- There should be a board/easel in the room.

### • Part 1. INTRODUCTION – 10 minutes

Hello, my name is ____, and on my left is _____. We will be leading the discussion this evening.

Thank you very much for coming out tonight.

There are stapled bundles of paper in front of you. We will turn to those shortly, but first, let's do some preliminary stuff. I will tell you when to open the packet.

How many people here have participated in a focus group before? ***[Show of hands]***

Focus groups are a way to better understand people's ideas and opinions. They are used, for example, to find out how people feel about a political candidate or a new product or some issue in the news. They are also useful in learning about people's attitudes and preferences on public policy issues.

Our goal tonight is to explore the ideas and opinions you have on some issues related to water in Long Beach. We are conducting these focus groups on behalf of a water research foundation. In today's session, we are talking to people who live in the Long Beach area.

Before we begin, I would like to go over some ground rules that will help keep us on track and make the discussion flow smoothly.

- ***Ground Rules***
- One person talks at a time.
- I want to hear from everyone tonight. If I haven't heard from you in a while, I might ask you to say what you are thinking.

- I am interested in <u>your</u> views and opinions. Please feel comfortable letting me know what you think, <u>even if it is different</u> from what others have said.
- Part of my job is to keep us on track. Questions may come up during the session, some I'll be able to answer, some I'll have to answer at the end, and some I may not know the answer to.
- These notes are for me to make sure I cover all the topics I'm supposed to and help make sure we stay on track.
- To help us keep your responses anonymous, please write only your first name on any materials I provide you throughout this discussion.
- We may not cover all of the information.
- Discuss refreshments.
- Restrooms (*tell people where the restrooms are*).
- Don't forget to get paid on your way out.
- Remember to turn off cell phones.
- Any questions before we get started?

## Part II. HOW YOU USE WATER – 15 minutes

As I said, the topic will be water. We are going to start out by talking about how much water people use and for what purpose.

## HANDOUT 1

Let's look at the papers in front of you. Put your name on the first page, then turn the page to what's called "Handout 1." Read the material there and answer questions as you come to them. When you come to a note to do so, just stop and we will discuss before moving on to the next handout. **[Wait until most people have finished]**

I see that most of you have finished. Let's go ahead and review some of your answers. What was your reaction to the information provided on the second page of this handout? **[Go around the table]**

How do you think your water use compares to these averages? **[Go around the table]**

Let's talk now about how you use water outdoors. How many of you use water to water your lawns or gardens? **[Show of hands]** How many of you use it to wash your cars? **[Show of hands]** How about for cleaning your walkway or driveway? **[Show of hands]** What about for washing your pets? **[Show of hands]** Do any of you use water outdoors for other reasons?

Now what about water that is used to maintain green spaces. What types of activities do you do outdoors that involve public green spaces that require watering? **[Call on 2 or 3 people to provide their answers]**

Does anyone happen to know how much water they use each year? **[Show of hands]**

## HANDOUT 2

Now turn the page and answer the questions on Handout 2.

Starting with the first question, how many of you pay your own water bill? **[Show of hands]**

If you don't pay a water bill, do you know who pays one for you? **[Ask for volunteers]**

Does everyone pay a bi-monthly bill? **[If not, ask how often]**

Do most of you pay one bill for water and sewer or are these services billed separately?

Can you tell me about how much you pay for water and sewer combined for your average water bill? **[Ask people who answered yes to question 1b]**

## HANDOUT 3

One issue I want to talk about in more detail is years when water is in short supply in the City of Long Beach. In other words, whether there is enough water from year to year or in most years to meet everyone's needs.

Please turn the page to Handout 3 and answer the questions on it.

Is water in short supply in some years in this area? **[Ask for volunteers] [PROBE: What seasons of the year do water shortages generally occur?]**

What do you remember about water shortages? **[Ask for volunteers] [PROBE: does anyone remember anything else?]**

What sorts of steps did your water provider take to deal with water shortages? **[PROBE: voluntary? Mandatory?]**

How much did the water shortages inconvenience you personally? **[Go around the table] [PROBE: if severe, how were you affected?]**

Did your household take any additional voluntary actions to reduce your indoor water use during past water shortages? **[Show of hands]** If yes, what actions did you take? **[Probe: Do you think that others reacted in similar ways if not what do you think they did?]**

Did your household take any voluntary actions to reduce your outdoor water use during past water shortages? **[Show of hands]** If yes, what actions did you take? **[Probe: Do you think that others reacted in similar ways if not what do you think they did?]**

**[If necessary]** Did your local water provider require your household to cut back on the use of water? **[show of hands] [PROBE: what did they do?] [Probe if necessary: what time of year, how long did it last, was the type or use limited or was it all use, do you remember why these restrictions were put in place by your local water agency]**

**[PROBE: Do you do anything different in years when water is short?]**

## HANDOUT 4

Please turn to the next page with Handout 4 at the top and answer the questions on it.

Do you think water supply shortages in the future will occur more often, about the same as now, or less often? Why do you feel that way? **[Go around the table]**

**[If not addressed, probe about growth and climate change]**

Do you know of steps that have already been taken to deal with future water shortages? **[Ask for volunteers]**

## HANDOUT 5

I'd like to get a better understanding of how you feel about different ways water agencies can ensure there is enough water to go around in the future.

Please turn to the next page of your handout, the one that says “Handout 5” at the top

To minimize future water shortages, Long Beach water providers are considering several alternatives to increase water supplies.

On Handout 5 is a list of potential options for addressing with future water needs. Please choose your 4 most preferred options. Put a “1” for your most preferred option, a “2” for your second most preferred option, and so on.

If you would like to rank more options, please feel free to do so. **[Wait for folks to finish]**

Let’s start with ________. What did you put down for your three most preferred options to reduce future water shortages and why do you prefer them? **[Go around the table]**

**(EASEL WORK/ Prep easel with the 12 items?)**

**Ask people if they have other ideas?**

***[If these ideas not mentioned probe: What about…?***

- ***Increase rates to prevent waste/reduce water use***
- ***Protection of water sources that are currently clean***
- ***Expanded water recycling (PROBE: reuse versus recycling)]***

**In thinking about these alternative sources that we just discussed, what concerns do you have?**

- ***What about fairness to downstream water users? Fairness to other parts of the state?***
- ***What about environmental concerns (e.g., fisheries and instream flows)?***
- ***What about limiting costs and rate increases?***
- ***What about enabling growth (or restricting growth)?***
- ***Other?***

**Prompt on:**

**Local vs. non-local groundwater sources – any reaction to taking in water from elsewhere (from someone else)?**

**Reuse / recycling of water for different types of uses – any strong reaction to possible reuse for replenishment of drinking water supplies?**

**Desalination: any strong reaction to feasibility, cost, or other aspects of ocean desal?**

- 

**Requiring new homes to have low water use irrigation**

- **Transfer from agricultural uses**

**Importing more Bay-Delta Water via Metropolitan Water District**

## HANDOUT 6

Now I would like you to turn to the next page in your handout, the one that says "Handout 6" at the top. This handout provides you with some background information and asks you to consider several options your water supplier could do to reduce future water shortages.

Walk people through the directions. Is it clear what we are asking you to do?

Please read the material and choose which option you prefer. When you are done, please put your pencils down. **[Wait for folks to finish]**

**Probes:**

**Description of the project attributes and levels**

**Were they clear?**

**Did the different levels of each come through?**

**Did they seem like good options?**

**Comparison of future water shortages**

**Were the pie charts clear?**

**Did it seem reasonable to you that the future could look like this?**

**Growth?**

**<u>Choice Tables</u>**

**Was it clear what you were supposed to do?**

**Was there enough information for you to make an informed choice?**

**If not, what additional information would be helpful?**

**Was there too much information?**

**What could be cut out?**

**What are the pie charts showing?**

**Is this helpful or confusing?**

**What did people choose?**

**Why – what was it about that option that made it your most preferred/**

**How certain are you about your choice?**

**[PROBE: was the information presented in the table helpful in making your decision? Were the pie charts helpful?]**

Which one of the alternative programs did you prefer and why? **[Go around the table]**

***[If time available:***

***a. How much would you like to see more real-time data on your water use? If this information was available, do you think that would affect your water use patterns?***

***b. Use of water budgets – would you opt to pay more above your budget?]***

Well, that's all the time we have this evening. Thank you very much for coming out tonight. I really appreciate all of your thoughts and opinions. Please leave all of your materials in front of you so that I can collect them. Don't forget to get paid on your way out.

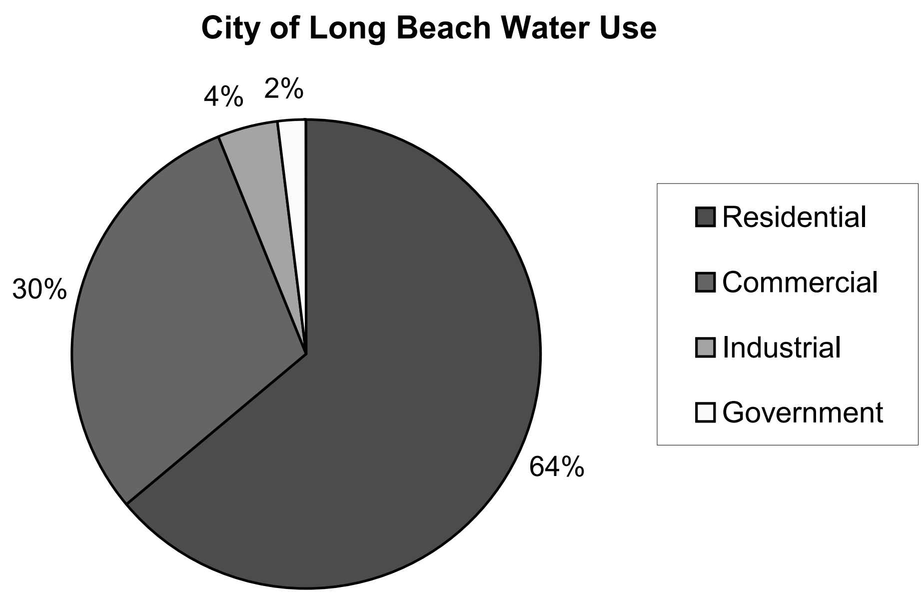
## B.3 Focus Group Participant Handout, Long Beach Example

**Your First Name: ______________________**

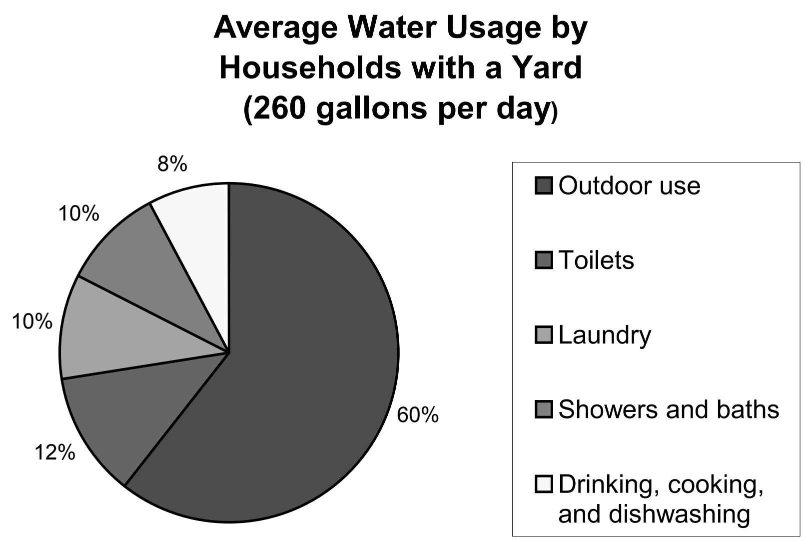
**Please do not turn to the next page until asked to do so by the moderator**

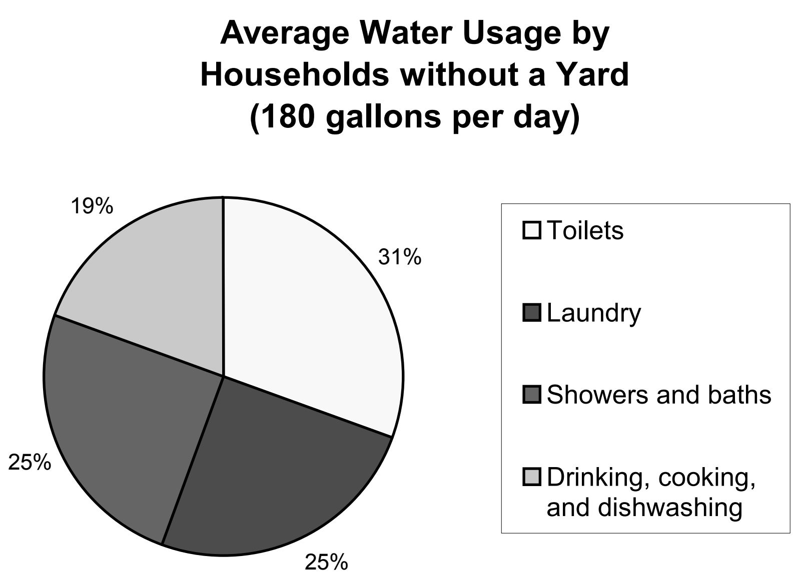
# HANDOUT 1

Currently, Long Beach Water Department's (LBWD's) residential, commercial, and industrial customers use approximately 20 billion gallons of water each year, which is enough to fill over 60,000 football fields with one foot of water. The pie chart below shows how much water is used for residential, commercial, industrial, and government purposes. Nearly two-thirds (64%) of the water produced by LBWD is used by residential customers.



The typical single family household in Long Beach uses an average of about 210 gallons of water per day. In the summertime, Long Beach residents use much more water than in the winter (average summer use is about 390 gallons per day). Typically 80% of household *summer* water use is outside, primarily for watering lawns and gardens. The pie charts below shows how much water is used throughout the year by residents living in an average household with a yard, and by residents living in an average household without a yard, for various purposes.



1. Did any of the information in the pie chart about the average residential customer's water use surprise you?

| | |
|---|---|
| Yes | ☐ |
| No | ☐ |

   a. If so, what surprised you?

2. How do you think your household's water use compares to the averages presented in the pie chart? Do you use more, less, or about the same in each category? Why?

3. What types of <u>outdoor</u> activities do you do <u>at your home</u> that involve using water? **(Please check <u>all</u> that apply)**

| | |
|---|---|
| Watering your lawn or garden | ☐ |
| Washing your car | ☐ |
| Swimming in your own pool | ☐ |
| Washing your pets | ☐ |
| Decorative fountains | ☐ |
| Cleaning your walkway or driveway | ☐ |
| Other (please specify) | ☐ |

4. What types of outdoor activities do you do <u>away from your home</u> that involve neighborhood parks and other public green spaces that require watering? **(Please check <u>all</u> that apply)**

| | |
|---|---|
| Walking, running, or picnicking in a public park | ☐ |
| Driving along green spaces | ☐ |
| Playing on sports fields | ☐ |
| Other (please specify_________________) | ☐ |

5. Are you connected to a public water supply system?

| | |
|---|---|
| Yes | ☐ |
| No | ☐ |

a. If no, do you know where you get your water?

| | |
|---|---|
| Private wells | ☐ |
| Other (please specify _________________) | ☐ |
| I don't know where my water comes from | ☐ |

**Please do not turn to the next page until asked to do so by the moderator.**

## HANDOUT 2

1. Do you pay your own water bill? **(Check <u>one</u> box)**

   Yes ☐
   No ☐

   a. If you answered no, do you know who pays your water bill (e.g., homeowners association, landlord)?

   b. If you answered yes, is your water and sewer bill combined or are they separate bills? Is your electricity cost also included in the same bill?

   c. If you do pay your water bill, how often are you billed (e.g., monthly, every two months)?

   d. If you know how much you pay for your water bill, about how much is your average monthly water bill? If you use more water in the summer than the winter, please make your best estimate for the average monthly amount.

   e. Have you noticed any increase in your water bill over the past few years?

**Please do not turn to the next page until asked to do so by the moderator.**

# HANDOUT 3

1. Is the amount of water available to households in your area in short supply in some years?

   Yes ☐
   No ☐

   a. If yes, how did the last water shortage affect your household?

2. Did your local water provider ever require <u>mandatory</u> cutbacks on your household's water use (e.g., restricting the days you can water your lawn)?

   Yes ☐
   No ☐

   a. If yes, what did they require you to do?

   b. If yes, how much did the actions taken by your water agency inconvenience you personally?

   Not at all ☐
   Slightly inconvenienced ☐
   Moderately inconvenienced ☐
   Very inconvenienced ☐
   Extremely inconvenienced ☐

3. Did your local water provider ever encourage <u>voluntary</u> cutbacks on your household's water use?

| | |
|---|---|
| Yes | ☐ |
| No | ☐ |

a. If yes, what did they encourage you to do?

4. Did your household take any additional <u>voluntary</u> actions beyond those required or encouraged by your water provider to reduce your water use during the last water shortage?

| | |
|---|---|
| Yes | ☐ |
| No | ☐ |

a. If yes, what did you do?

5. How did the water shortage affect your <u>indoor</u> water use? Please explain.

6. How did the water shortage affect your <u>outdoor</u> water use? Please explain.

7. Do you feel that the water shortage affected your indoor or outdoor water use more? Please explain.

**Please do not turn to the next page until asked to do so by the moderator.**

# HANDOUT 4

1. Do you think water supply shortages in the future will occur more often, about the same as now, or less often?

| | |
|---|---|
| More often | ☐ |
| About the same as now | ☐ |
| Less often | ☐ |
| I don't expect water shortages in the future | ☐ |

   a. Why do you feel water supply shortages will occur more often, less often, or about the same as now?

2. Do you know of steps that have already been taken by your local water provider to deal with future water shortages? If so, please write them in the space below.

**Please do not turn to the next page until asked to do so by the moderator.**

# HANDOUT 5

To minimize future water shortages, Long Beach's water provider, LBWD, is considering several alternatives to increase water supplies for the future. Below is a list of several options for addressing future water shortages. Please choose your 4 most preferred options. Put a "1" for your most preferred option, a "2" for your second most preferred option, and so on. If you would like to rank more options, please feel free to do so.

| Rank | Options for dealing with future water shortages |
|---|---|
| ________ | Increasing the amount of water that is imported from Northern California (from the Bay-Delta) and purchased from the Metropolitan Water District (MWD) |
| ________ | Increasing available supplies of water by transferring more water from agricultural uses in the state to Long Beach or MWD |
| ________ | Investing in desalination facilities, to convert ocean waters into part of the local potable supply |
| ________ | Increasing the price of water to residential, commercial, and industrial users so they will use less |
| ________ | Requiring low water landscaping (e.g., xeriscape) in new homes and redevelopment projects |
| ________ | Increasing available supplies of water by expanding the use of local groundwater (i.e., water found underground and accessed by wells) |
| ________ | Expanding water reuse for outdoor irrigation and industrial uses |
| ________ | Using highly treated recycled water to replenish the local groundwater supply |
| ________ | Increasing available supplies in dry years by acquiring more imported MWD water is wet years, and storing it underground for use in dry years |
| ________ | Promoting more voluntary water conservation through additional education and incentives (e.g., rebates to convert to low water landscaping and water efficient appliances) |

**Please do not turn to the next page until asked to do so by the moderator.**

# HANDOUT 6

Water shortages are defined by the amount of water available in a given year. When there is not enough water to meet current needs, there is a shortage and people have to reduce the amount of water they use.

In many parts of California, and elsewhere throughout the western U.S., water shortages and water use restrictions are common. These shortages may be caused by several factors including drought, reduced levels of snow in mountains that feed our MWD water supplies and groundwater, regulations or Court rulings that limit the amount of non-local water that can be imported to the City, or earthquakes or other events that may disrupt the flow of imported water into the local region.

Typically if there is only a small shortfall in the amount of available water, the reductions can be met through voluntary cutbacks or minimal restrictions. When there are more severe water shortages, water providers are likely to require greater reductions in the amount of water you can use.

To reduce the likelihood of a severe water shortage, the Long Beach Board of Water Commissioners adopted a number of water use prohibitions that have been incorporated into city code. These “permanent” water use prohibitions are in place year-round. They include restrictions on outdoor landscape watering. For example, landscape irrigation is limited to 15 minutes per area on Monday, Thursday, and Saturday after 4:00 p.m. and before 9:00 a.m., and water is not allowed to run off irrigated landscape areas onto sidewalks and streets.

The permanent water use prohibitions have helped to substantially reduce water demand in Long Beach. However, severe water shortages may still occur. In the event of a drought or other water shortage event, the LBWD’s Board of Water Commissioners has the authority to issue a declaration of Imminent Supply Shortage, which establishes mandatory water conservation measures and prohibited uses of water, based on three stages of water shortage. Mandatory water use restrictions under each stage are as follows:

- **Stage 1 Water Supply Shortage**. In addition to the permanent water use restrictions described above, Stage 1 water use restrictions include:
    - Landscape watering only on Mondays and Thursdays after 4:00 p.m. and before 9:00 a.m., between the months of October and April
    - Filling residential swimming pools and spas with potable water is not allowed

Stage 1 restrictions (or their equivalent) have been necessary in 5 of the past 20 years.

- **Stage 2 Water Supply Shortage**. In addition to the permanent water use restrictions, Stage 2 water use restrictions include:

    - Stage 1 water restrictions

    - Landscape watering only on Monday or Thursday after 4:00 p.m. and before 9:00 a.m., year-round

    Stage 2 restrictions (or similar rules) have been required in Long Beach in 3 of the past 20 years.

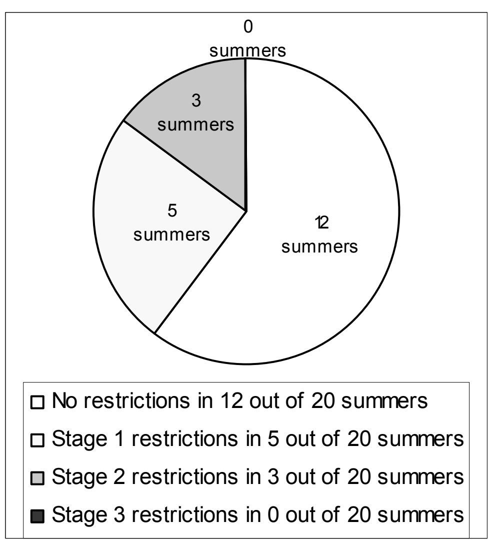
- **Stage 3 Water Supply Shortage.** In addition to the permanent water use restrictions, under Stage 3 water use restrictions:

    - Most outdoor water use would not be allowed

    - Additional water use restrictions may be put in place by the Board as necessary

    There have been no “Stage 3” restrictions put in place in the last 20 years in Long Beach.

The pie chart below shows how often the different water use restrictions have been in place in this region over the last 20 years.



There are a number of actions that water providers can take to address future residential water use shortages. These include:

**Increasing groundwater use**

Groundwater is water that collects or flows beneath the Earth's surface, filling the porous spaces in soil, sediment, and rocks. Groundwater originates from rain and from melting snow and ice in the mountains and is the source of water for aquifers, springs, and wells. With careful planning and state approval, the use of groundwater from local or non-local sources may be increased to expand available drinking water supplies.

**Importing or transferring additional water to the region**

Additional water supplies could be created by importing more water from outside of Long Beach (such as purchasing Bay-Delta water from MWD), or by improving agricultural water use practices and transferring the saved water from agricultural uses to residential uses.

**Increasing water storage**

Water storage could be expanded by purchasing additional imported Bay-Delta water from MWD in years when Northern California Bay-Delta waters are more plentiful, and storing it underground in the local groundwater basin, where it could be extracted and used in dry years.

**Increasing the amount of water conservation**

Increased water conservation actions could include rebates for water saving appliances or for converting to low water use landscaping. Alternatively, mandatory low water landscaping could be required of new homes and redevelopment projects.

**Increasing the recycling of water**

After water is highly treated, it can be reused for watering of public landscape areas, parks, and golf courses. Also, after it is highly treated, recycled water can be used to replenish existing local groundwater supplies and later reused for drinking water.

**Adding desalinated water**

Saltwater, such as found in the Pacific Ocean, can be transformed into high-quality fresh water through the use of a variety of advanced water treatment processes. Desalination facilities can be built to provide fresh water to supplement the City's other supplies.

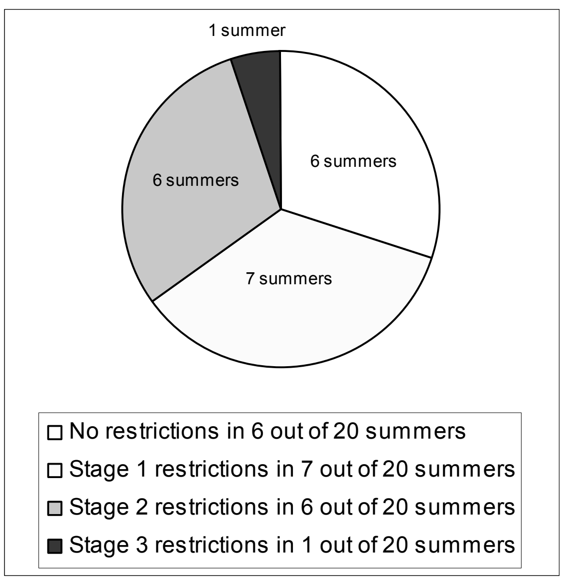
The questions on the next page ask you to choose among alternative programs that could be implemented to address future water shortages in Long Beach. These programs would be in addition to other projects that are already planned or in progress.

Each of the potential additional programs has different combinations of actions and would cost your household different amounts of money.

The different programs involve different combinations of actions that would reduce the frequency and severity of future water shortages by enhancing local and/or imported water supplies. Some programs do more than others, but those programs typically also cost more.

Even without any additional water programs put in place, it is expected that your annual water bill will increase due to ongoing improvements and general cost increases faced by your water provider.

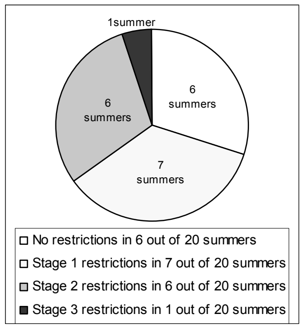
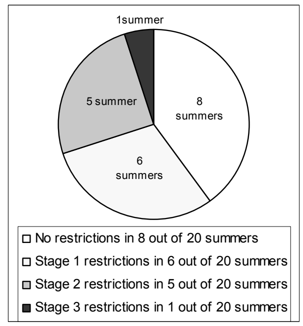
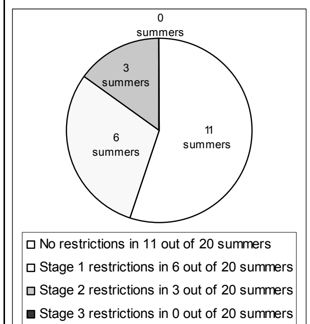
Given expected future growth, with only the currently planned water supplies, the number and severity of water shortages will increase. The pie chart below shows the expected change in water use restrictions over the next 20 years if no additional actions are taken to address future water needs.

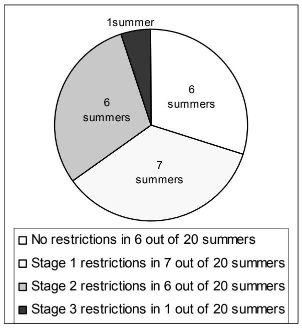
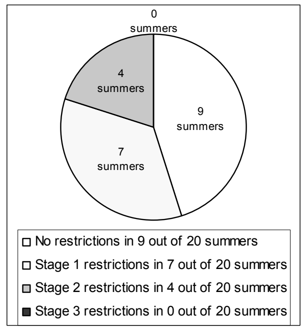
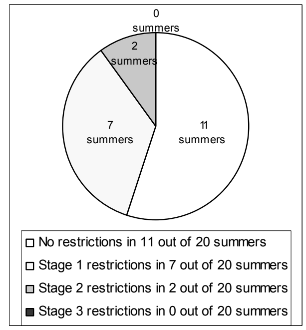



**Expected future with no new actions**

The tables on the next two pages present options for addressing future water needs. At the bottom of each table, you are asked to choose which of the programs you prefer. Make a preferred choice on each page.

Remember, if you choose to spend additional money for an additional water program, that money won't be available for you to buy other things. If you do not want to spend additional money to reduce future water use restrictions, you should check the No Additional Actions box as your preferred option.

| | No Additional Actions | Plan A | Plan B |
|---|---|---|---|
| **Addition to your <u>annual</u> water cost each year for the next 20 years.** | $1 per month, which would be $12 per year | $10 per month, which would be $120 per year | $25 per month, which would be $300 per year |
| **Available water supply such that water use restrictions in the next 20 years will be:** |  |  |  |
| **Which option do you prefer? *Check <u>one</u> box.*** | ☐ | ☐ | ☐ |

| | No Additional Actions | Plan C | Plan D |
|---|---|---|---|
| **Addition to your <u>annual</u> water cost each year for the next 20 years.** | $1 per month, which would be $12 per year | $18 per month, which would be $216 per year | $30 per month, which would be $360 per year |
| | | | |
| **Available water supply such that water use restrictions in the next 20 years will be:** |  |  |  |
| | | | |
| **Which option do you prefer? *Check <u>one</u> box.*** | ☐ | ☐ | ☐ |

*Appendix C*

# Value of Water Supply Reliability Survey Instrument

## C.1 Austin Version

Screen shots from the Survey Instrument are provided below.

**Your Views on Issues in Texas**

We are faced with many issues in Texas, none of which can be solved easily or inexpensively. Below is a list of some of these issues. Some of them may be important to you personally, others may not be important to you personally. How important are the following issues to you?

Select one answer from each row in the grid

| **Issues in Texas** | Not Important At All | Slightly Important | Moderately Important | Very Important | Extremely Important |
|---|---|---|---|---|---|
| Improving education in public schools | ○ | ○ | ○ | ○ | ○ |
| Improving local libraries | ○ | ○ | ○ | ○ | ○ |
| Increasing water supplies | ○ | ○ | ○ | ○ | ○ |
| Reducing crime | ○ | ○ | ○ | ○ | ○ |
| Helping farmers increase their incomes | ○ | ○ | ○ | ○ | ○ |
| Reducing taxes | ○ | ○ | ○ | ○ | ○ |

Next

Screen 1

This survey focuses on issues related to water in the Austin metropolitan area.

Decisions are being made now that will affect the amount of water we have available in the future. Austin area water suppliers are interested in your views and opinions to help inform them as they make these decisions.

Next

Screen 2

Screen 3

How long have you lived in the Austin metro area?

Select one answer only

- ○ Less than 1 year
- ○ 1-2 years
- ○ 3-5 years
- ○ 6-10 years
- ○ More than 10 years

Next

Screen 4

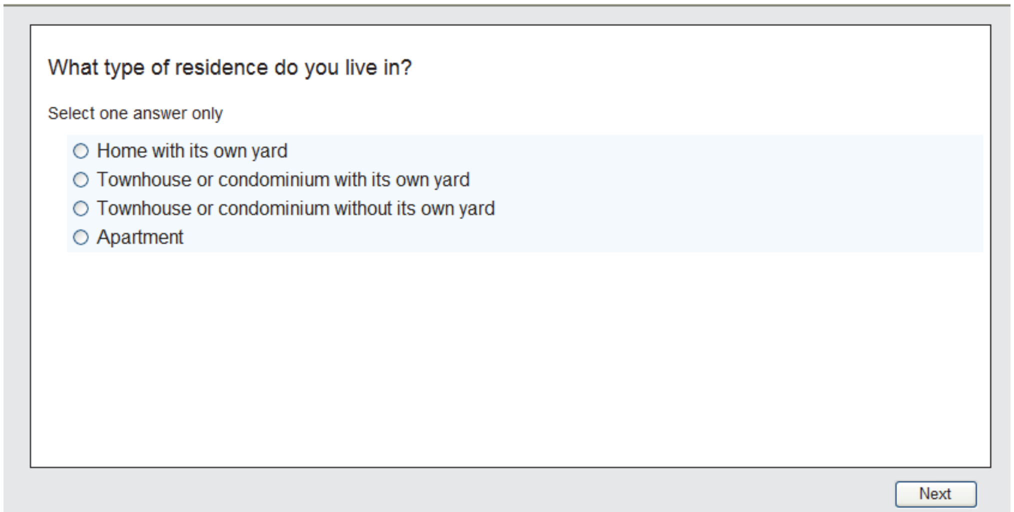
How would you rate your local water supplier's performance in the following areas?

Select one answer from each row in the grid

| **Area** | Not good at all | Slightly good | Moderately good | Very good | Extremely good |
|---|---|---|---|---|---|
| Making sure you have enough water | ○ | ○ | ○ | ○ | ○ |
| Providing safe and healthy drinking water | ○ | ○ | ○ | ○ | ○ |
| Providing good tasting drinking water | ○ | ○ | ○ | ○ | ○ |
| Promoting water conservation | ○ | ○ | ○ | ○ | ○ |

Next

Screen 5

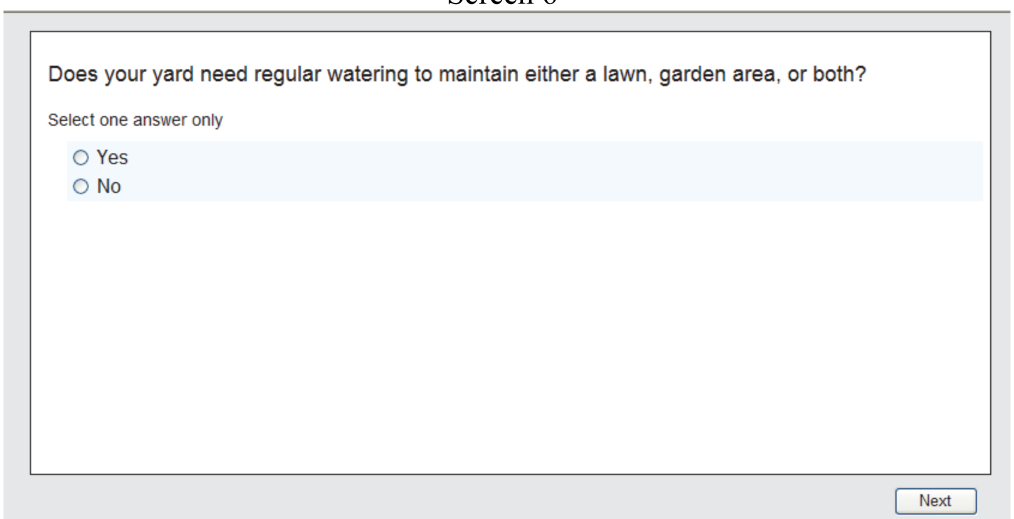

What type of residence do you live in?

Select one answer only

- Home with its own yard
- Townhouse or condominium with its own yard
- Townhouse or condominium without its own yard
- Apartment

Next

Screen 6[5]


Does your yard need regular watering to maintain either a lawn, garden area, or both?

Select one answer only

- Yes
- No

Next

1. [5]. Screen 6 reflects the choice made in Screen 5.

## Screen 7

Do you use or enjoy public parks, athletic fields, or other public green spaces that rely on outdoor watering?

Select one answer only

- ○ Yes
- ○ No

Next

## Screen 8

Who pays your water bill?

Select one answer only

- ○ My household pays its own water bill
- ○ My landlord pays the water bill
- ○ My water bill is part of my HOA fees
- ○ Other specify: ______
- ○ I don't know how my water bill is paid

Next

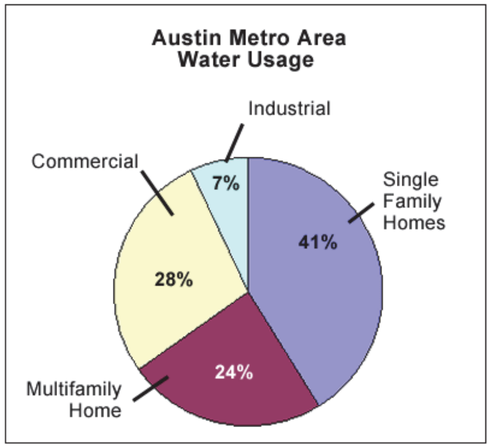
## Screen 9

The next few screens will provide information about the sources and amount of water used in the Austin metro area.

Next

Screen 10

Water suppliers in the Austin metro area provide just over 56 billion gallons of water each year for a variety of different users. The pie chart below shows how much water is used for single- and multifamily homes and commercial and industrial purposes. About 2/3rds (65%)of this water goes to residential customers.




Next

Screen 11

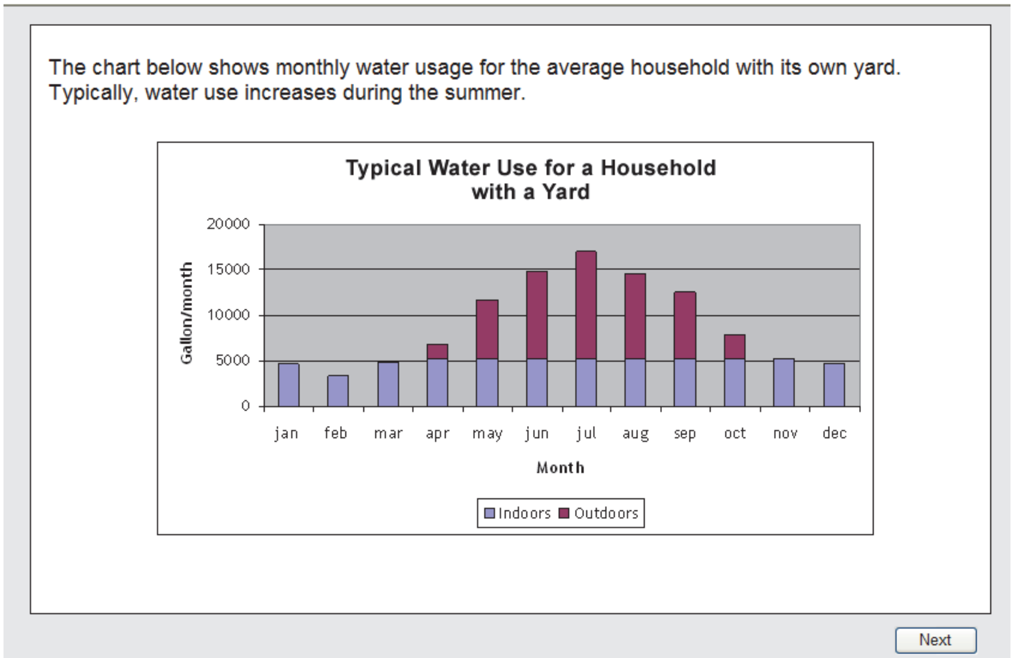
The actual amount of water any one household uses depends on:

- The number of people who live in the house;
- What type of home it is, such as houses with their own yards, townhomes, condominiums, or apartments; and
- The amount and type of outdoor landscaping.

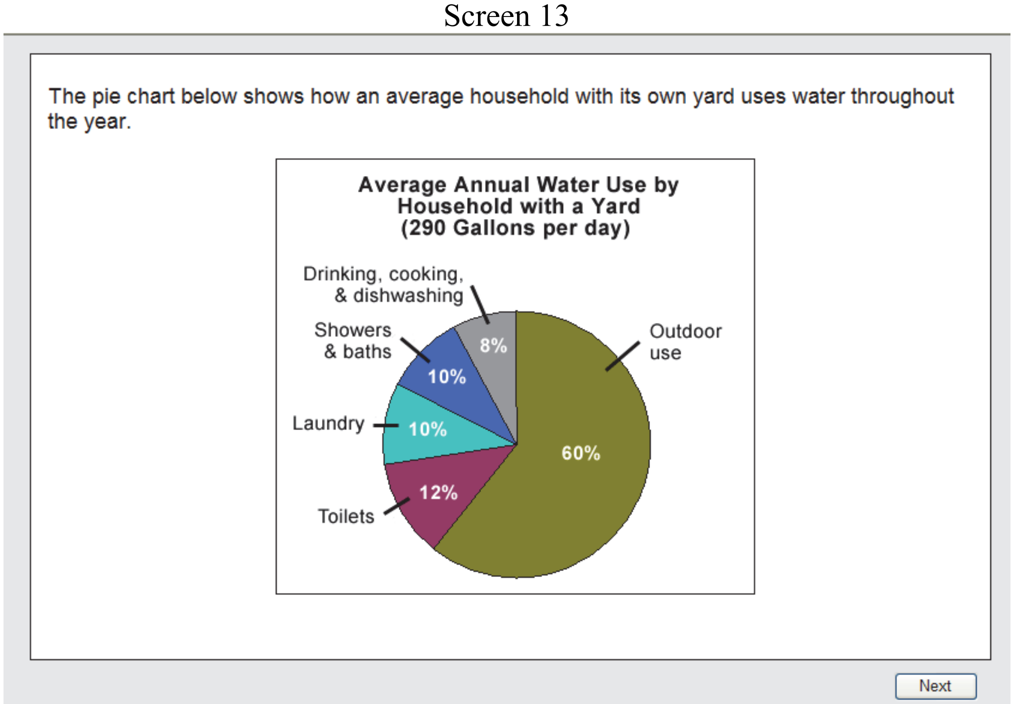
The typical household with its own yard in the Austin metro area, on average, uses 290 gallons of water per day or about 105,000 gallons per year. Most of this water is used during the summer months for watering lawns and gardens.

Next

Screen 12

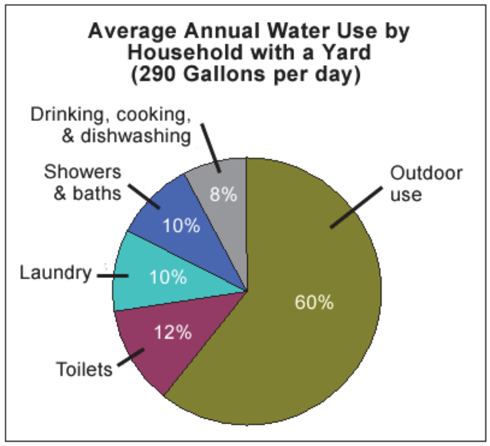



Screen 13



Screen 14

In thinking about how your household uses water compared to the averages presented in the pie chart, does your household use more, less, or about the same amount of water for <u>outdoor</u> use?




Select one answer only

- ○ More
- ○ Less
- ○ About the same

Next

Screen 15

**CURRENT SUPPLIES WILL NOT MEET FUTURE DEMAND**

The goal of water suppliers is to match available water supplies with demand by taking into account river flow, reservoir storage, climate, customer demand, and population estimates. This helps to ensure that there will be an adequate supply of clean water in the future.

Even after accounting for savings associated with the existing and planned water conservation activities, we expect growing water demands in the Austin metro area over the next 20 years. Growing demands, coupled with uncertainty over future rainfall and river levels, means that water demands will periodically exceed the available water supply in several of the next 20 years.

To achieve the goal of ensuring an adequate supply of clean water, water suppliers in the Austin metro area are considering options to make sure that enough water is available in the future. For this reason, water suppliers are interested in your views of whether some options for avoiding future water shortages should be taken.

Water suppliers do not want to implement new options unless people are willing to pay for them. One way to find out about this is to give people like you information about possible new options, so that you can make up your own mind about them.

Some people think the options they are asked about are not needed; others think they are. We want to get the opinions of all kinds of people.

Next

## Screen 16

**Methods to Address Current Water Shortages**

In this region, in addition to voluntary water conservation measures, there are some water use rules that are always in place. These permanent restrictions include:

- No outdoor watering between 10 a.m. and 7 p.m.
- Water should not run off pavement surfaces
- No watering on rainy or very windy days
- Leaks should be fixed quickly

Next

When there is not enough water to meet demand, mandatory water use restrictions become necessary, and they can have significant effects on residents, businesses, and public parks. When needed, water use restrictions are typically put in place during summer and fall months.

Water suppliers in the Austin metro area currently have three levels of mandatory water use restrictions to address water shortages. The level selected depends on the severity of water shortages. These restrictions typically apply from May 1 through September 30 , but some water use restrictions also apply at other times when water supplies are insufficient to meet needs.

Stage 1 restrictions apply every year from May through September, and include the following limits for residential customers:

- Watering of lawns, gardens, and public parks is limited to no more than twice a week on designated days.
- Watering by sprinkler or irrigation is allowed only on designated days, before 10:00 a.m. and after 7:00 p.m.
- Watering with a hand-held hose or hand-held bucket is allowed at any time.

Stage 2 restrictions include the following limits for residential and other customers:

- Watering of lawns, gardens, and public areas with a hose-end sprinkler, a soaker hose, or drip irrigation is allowed only on designated outdoor water use days, and must occur before 10:00 a.m. and after 7:00 p.m.
- Watering of lawns, gardens, and public areas with a permanently installed automatic irrigation system is allowed only on designated outdoor water use days, and must occur between midnight and 10:00 a.m.
- Watering of lawns, gardens, and public areas with a hand-held hose or a hand-held bucket can occur at any time.

Screen 17

- Home vehicle washing using a hand-held bucket or hose with a shutoff nozzle is allowed only on designated outdoor water use days, and must occur before 10:00 a.m. and after 7:00 p.m.
- Water is served in restaurants only upon request.

Stage 3 restrictions include the following limits for residential and other customers:

- Watering of lawns, gardens, and public areas is allowed only with a hand-held hose or a hand-held bucket, is limited to designated outdoor water use days, and is limited to 6:00 a.m. to 10:00 a.m. and 7:00 p.m. to 10:00 p.m.
- No use of automatic irrigation systems.
- No vehicle washing at all.
- No operation of outdoor ornamental fountains or structures making similar use of water, other than the aeration necessary to preserve habitat for aquatic species.
- No filling of swimming pools, fountains, or ponds.
- No installation of new landscaping.

Next

Screen 18

Stage 2 restrictions can lead to brown lawns and temporary damage to landscaping for households and public parks.

- Lawns and landscaping can recover if these restrictions are needed for only one summer.
- If water shortages require Stage 2 restrictions multiple years in a row, this can lead to dead lawns and landscaping for households and public parks.
- Dead lawns and landscaping would require replacement or conversion to low-water use landscaping (e.g., xeriscape).

Stage 3 restrictions can lead to dead lawns and landscaping for households and public parks after only one year.

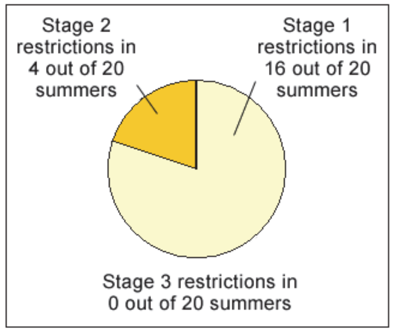
Next

Screen 19

Stage 1 restrictions occur every year between May 1 and September 30. Stage 2 and Stage 3 water use restrictions are put in place if water shortages become more severe or prolonged.

Stage 2 restrictions have been needed during four summers over the last 20 years.

Stage 3 restrictions have not been needed in the last 20 years. The pie chart below illustrates how often Stage 2 restrictions have been needed in the last 20 years.




Next

Screen 20

**Water Suppliers Need to Identify a Water Supply Strategy**

Developing new water supplies can help reduce the frequency and severity of future water shortages. Water suppliers are developing a Long-Term Reliable Water Supply Strategy to evaluate how much, if any, additional water supplies should be developed to meet future needs.

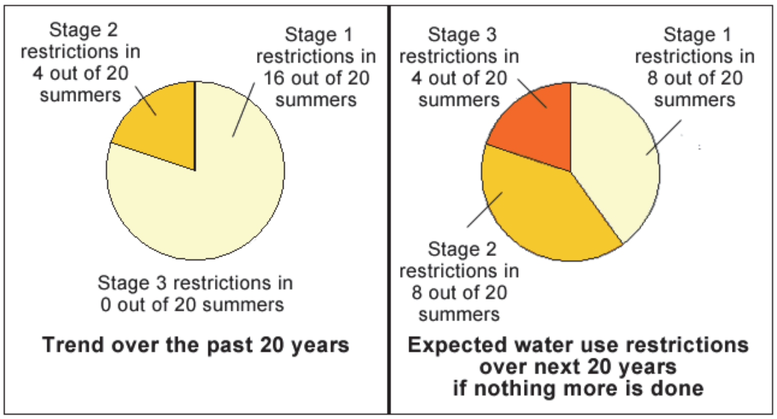
While additional water supplies are not mandatory, without new supplies, water use restrictions will become more severe and frequent in the future.

Next

## Screen 21

The two pie charts below compare the frequency of water use restrictions in the past with expected restrictions that will be needed in the future if no new water supplies are developed.

- The pie chart on the left shows that in the past, Stage 2 restrictions have been needed four out of the past 20 years. This is the same chart you saw on a previous screen.
- The pie chart on the right shows that Stage 2 restrictions are likely to be more frequent in the future than in the past, and Stage 3 restrictions will be needed for the first time if no new water supplies are developed.




Next

## Screen 22

**Your Opinion on How Much Should be Done to Increase Future Water Supplies**

The more water supplies that are developed to meet future needs, the more you will have to pay for water in the future. These costs would be passed on to you through your monthly water bill, increased HOA fees, or rent.

Water suppliers do not want to develop new water supplies unless people like you are willing to pay for them. For this reason, they are trying to balance the amount of water supplies in the future against the costs you would face.

On the next three screens, you will have an opportunity to provide your views on reducing the severity of future water use restrictions based on six alternative water supply plans. In later sections, you can provide your opinions on different options for how additional future water supplies, if any, should be developed.

Next

In the table below, you are presented with expected levels of future water use restrictions given different future water supply plans. The tables also show the increased costs to you.

The first row uses pie charts to show the frequency of different stages of water use restrictions in the next 20 years given different levels of available water supply.

Under the No Additional Actions column, Stage 1 water use restrictions will be in place 8 of the next 20 summers, Stage 2 restrictions will be in place 8 of the next 20 summers, and Stage 3 restrictions in 4 of the next 20 summers.

Over the past 20 years, Stage 1 restrictions have occurred in 16 summers, Stage 2 restrictions have occurred in 4 summers, and there have been no Stage 3 restrictions.

If you would like to be reminded of the permanent water use restrictions, and Stage 1, Stage 2, and Stage 3 restrictions, please click the button on the right. Click here

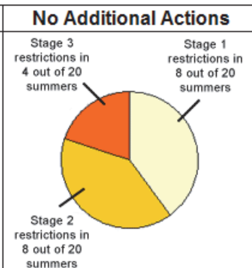
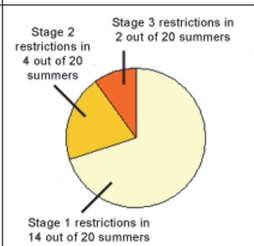
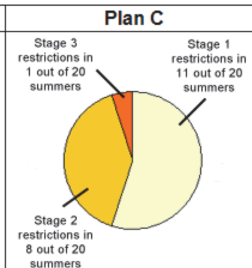
Water Supply Plans B and C both increase water supplies and have different levels of future restrictions.

The second row of the table shows the increase in your water cost under each plan. Under the No Additional Actions column, your monthly water costs will increase by $1, which means that you will pay an additional $12 per year.

If you choose to spend money for a plan that increases water supplies, that money will not be available for you to buy other things.

Please review the table and check the box under the plan you most prefer.

Screen 23

| | No Additional Actions | Plan B | Plan C |
|---|---|---|---|
| Available water supply such that water use restrictions in the next 20 years will be: |   |   |   |
| Increase in your water cost | $1 per month, which would be $12 per year | $11 per month, which would be $130 per year | $13 per month, which would be $160 per year |
| **Which plan do you prefer?** | ○ | ○ | ○ |

Next

## Screen 24[6]

Please provide a brief comment to help us understand why you chose $11 per month, which would be $130 per year as your most preferred plan.

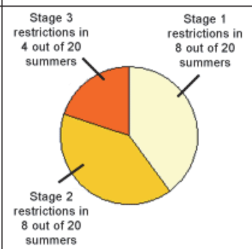
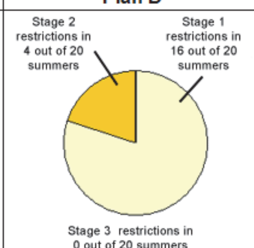
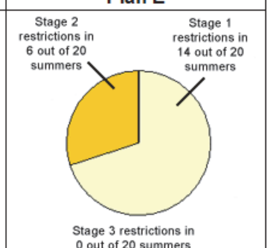
Type in the answer

Next

## Screen 25

This table presents some additional expected future water use restrictions in the next 20 years based on alternative water supply plans at different costs to you.

Please review the table and check the box under the plan you most prefer.

| | No Additional Actions | Plan D | Plan E |
|---|---|---|---|
| Available water supply such that water use restrictions in the next 20 years will be: |  |  |  |
| Increase in your water cost | $1 per month, which would be $12 per year | $15 per month, which would be $180 per year | $13 per month, which would be $150 per year |
| **Which plan do you prefer?** | ○ | ◉ | ○ |

Next

---

2. [6] Screen 24 reflects the choice made in Screen 23.

Screen 26[7]

Please provide a brief comment to help us understand why you chose $15 per month, which would be $180 per year as your most preferred plan.

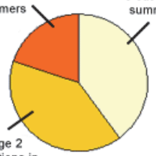
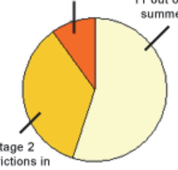
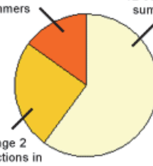
Type in the answer

Next

Screen 27

This table presents some additional expected future water use restrictions in the next 20 years based on alternative water supply plans at different costs to you.

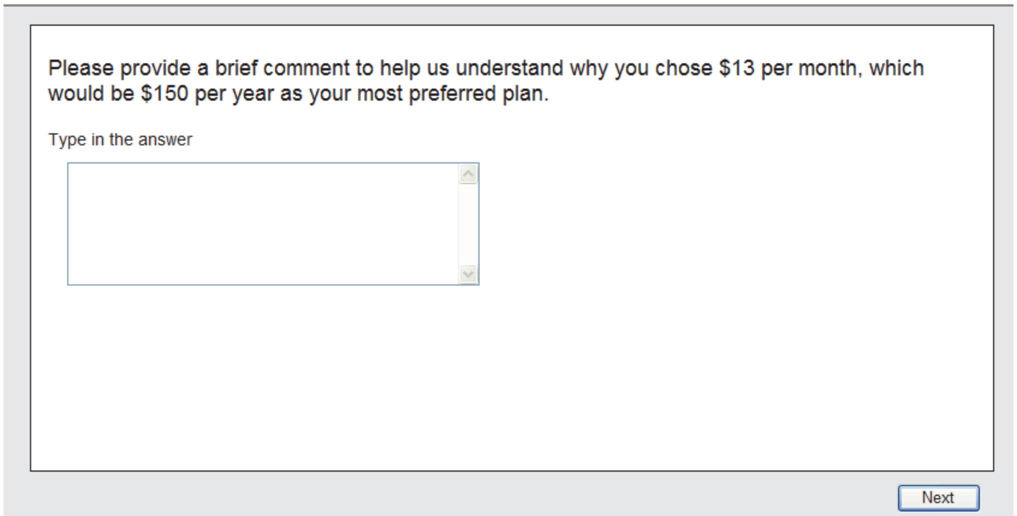
Please review the table and check the box under the plan you most prefer.

| | No Additional Actions | Plan F | Plan G |
|---|---|---|---|
| Available water supply such that water use restrictions in the next 20 years will be: | Stage 3 restrictions in 4 out of 20 summers<br>Stage 1 restrictions in 8 out of 20 summers<br><br>Stage 2 restrictions in 8 out of 20 summers | Stage 3 restrictions in 2 out of 20 summers<br>Stage 1 restrictions in 11 out of 20 summers<br><br>Stage 2 restrictions in 7 out of 20 summers | Stage 3 restrictions in 3 out of 20 summers<br>Stage 1 restrictions in 12 out of 20 summers<br><br>Stage 2 restrictions in 5 out of 20 summers |
| Increase in your water cost | $1 per month, which would be $12 per year | $13 per month, which would be $150 per year | $8 per month, which would be $90 per year |
| **Which plan do you prefer?** | ○ | ○ | ○ |

Next

3. [7]. Screen 26 reflects the choice made in Screen 25.

Screen 28[8]

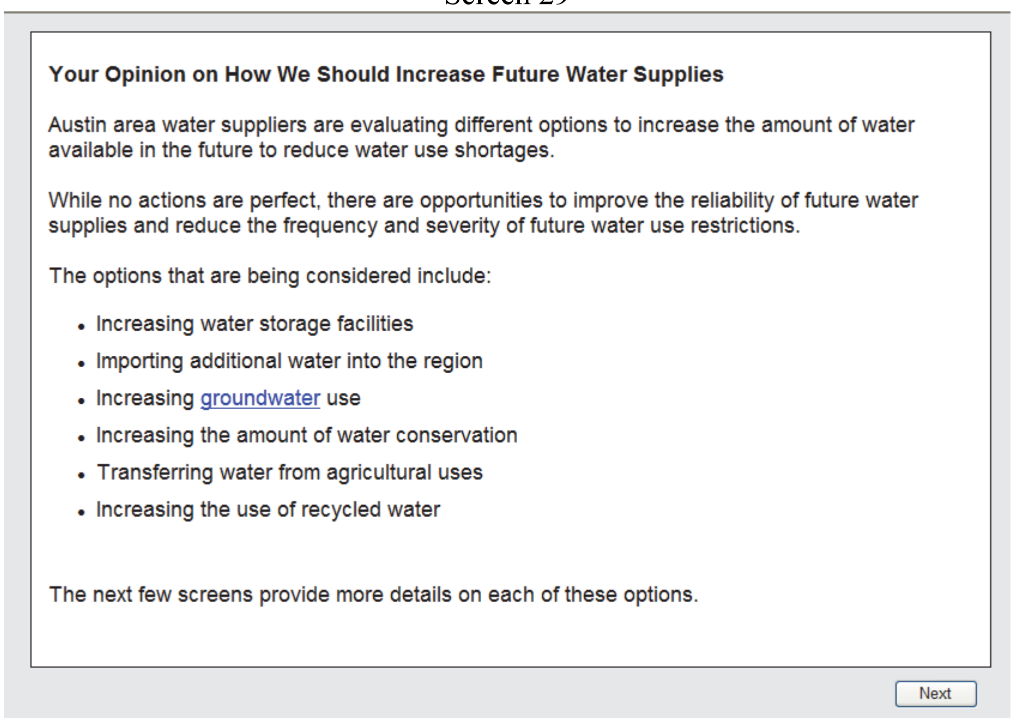


Please provide a brief comment to help us understand why you chose $13 per month, which would be $150 per year as your most preferred plan.

Type in the answer

Next

Screen 29



**Your Opinion on How We Should Increase Future Water Supplies**

Austin area water suppliers are evaluating different options to increase the amount of water available in the future to reduce water use shortages.

While no actions are perfect, there are opportunities to improve the reliability of future water supplies and reduce the frequency and severity of future water use restrictions.

The options that are being considered include:

- Increasing water storage facilities
- Importing additional water into the region
- Increasing groundwater use
- Increasing the amount of water conservation
- Transferring water from agricultural uses
- Increasing the use of recycled water

The next few screens provide more details on each of these options.

Next

4. [8]. Screen 28 reflects the choice made in Screen 27.

Screen 30

**Increasing water storage facilities**

Increased water storage facilities could be created by:

- Developing underground reservoirs (groundwater storage) to store additional water in wet years for use in dry periods.
- Increasing the capacity of reservoirs on the Lower Colorado River.

Additional storage would allow water suppliers to store more water in years when water is plentiful for use in dry years.

While increasing the size of existing surface reservoirs could create additional recreation opportunities on these reservoirs, it might also cause the loss of some property along the reservoirs' current shoreline and the need to replace some recreational access points. It also might have some negative effects on ecosystems, including:

- Loss of river and wildlife habitat
- Decreased flows in some rivers at some times of the year, which could impact some fish and other types of wildlife that rely on adequate stream flows

Next

Screen 31

**Transferring water from agricultural uses**

Improvements in how agriculture uses water could be made, which would reduce the amount of water that is needed by farmers. The saved water could be transferred to the Austin area for residential and business use. Water could be saved by having Austin metro area water suppliers:

- Pay for the use of improved agricultural irrigation systems that can reduce the amount of water lost to evaporation
- Pay the extra cost for farmers to use new plant breeds that can provide the same harvest with less water.

Next

Screen 32

**Increasing groundwater use**

Groundwater is water that collects or flows beneath the Earth's surface, filling the porous spaces in soil, sediment, and rocks. Groundwater originates from rain and from melting snow and ice and is the source of water for aquifers, springs, and wells. Groundwater from both local and non-local sources can be used for drinking water supplies.

Use of non-local groundwater supplies would require the installation of additional pipelines and pumps to transfer water to the Austin area, and have increased energy costs associated with moving the water to the Austin metro area.

Use of local groundwater supplies would reduce the amount of water available in local springs and natural pools.

Next

Screen 33

**Increasing the use of recycled water**

Most of the water used in the Austin metro area is treated and discharged to the Lower Colorado River , and flows out of the region. Some of the treated water can be used again in the Austin metro area. After it is treated, recycled water can be used:

- For watering public landscape areas, parks, and golf courses.
- To replenish groundwater reservoirs. This water can later be treated again and used for drinking water.
- For some industrial processes, such as cooling in power plants.

There are currently opportunities to increase the amount of recycled water in the Austin metro area

Next

Screen 34

**Increasing the amount of water conservation**

Increased water conservation actions could include:

- Rebates for water saving appliances
- Rebates for converting to low-water use landscaping (e.g., xeriscape)
- Mandatory low-water landscaping for new homes.

A lot of individual water conservation measures have already been taken by residents and businesses in the Austin metro area. However, there are still opportunities for additional conservation measures, especially for reducing outdoor water use by giving up lawns at homes, athletic fields, and public parks.

Next

Screen 35

**Importing additional water into the region**

Additional water supplies could be created by importing water from outside the Lower Colorado River basin.

Importing water from outside the Lower Colorado River basin may have some negative consequences. Removing water from other rivers and lakes could:

- Impact ecosystems and recreational opportunities
- Limit the amount of water available to people living near the rivers from which the water is exported to Austin
- Increase energy costs associated with moving the water to the Austin metro area

Next

**Your Opinion on How We Should Meet Future Water Needs**

In the table below, you are presented with different options that water suppliers could undertake to improve the future water supply reliability.

Please rank your top 5 options for increasing our future water supply according to your personal views. If you want to rank more, please feel free to do so.

Put a "1" for the option you would first like to see done to reduce future water shortages, a "2" next to your second most preferred option, and so on until you have ranked at least 5 options.

Type in the answer into each cell in the grid

| | |
|---|---|
| Increasing the use of non-local groundwater sources | |
| Increasing the price of water to residential, commercial, and industrial users so they will use less | |
| Requiring low water landscaping in new homes (e.g., xeriscape) | |
| Increasing available supplies of water by expanding storage reservoirs or building new reservoirs | |
| Increasing the use of local groundwater sources | |
| Expanding water recycling for outdoor irrigation and industrial uses | |
| Promoting voluntary water conservation through education and incentives (e.g., rebates) | |
| Expanding water recycling to replenish groundwater reservoir supplies | |
| Increasing available supplies of water by importing more water from outside the Lower Colorado River basin | |
| Increasing available supplies of water by transferring more water from agricultural uses | |

Screen 36

Next

Screen 37

Of these five options, which do you like the least?

Select one answer only

- ○ Increasing available supplies of water by importing more water from outside the Lower Colorado River basin
- ○ Increasing available supplies of water by transferring more water from agricultural uses
- ○ Increasing the use of non-local groundwater sources
- ○ Increasing the price of water to residential, commercial, and industrial users so they will use less
- ○ Increasing available supplies of water by expanding storage reservoirs or building new reservoirs

Next

Screen 38

**Does it Matter How We Reduce Future Water Shortages?**

There are different ways that water suppliers can provide the same amount of water supply in the future. The next few questions ask you to choose among options that could be implemented to reduce the frequency of water shortages in the future. For each of the following questions, please indicate what option you prefer.

Next

Screen 39

**Does it Matter How We Reduce Future Water Shortages?**

There are different ways that water suppliers can provide the same amount of water supply in the future. The next few questions ask you to choose among options that could be implemented to reduce the frequency of water shortages in the future. For each of the following questions, please indicate what option you prefer.

Next

Screen 40

Of the two water storage options below, which do you prefer?

Select one answer only

- ○ Increasing underground water storage
- ○ Increasing surface reservoir storage

Next

Screen 41

Of the two groundwater water options below, which do you prefer?

Select one answer only

- ○ Increasing use of local groundwater sources
- ○ Increasing use of non-local groundwater sources

Next

Screen 42

Of the two water transfer and import options below, which do you prefer?

Select one answer only

- ○ Increasing water transfers from agriculture
- ○ Increasing water imports from outside the Lower Colorado River basin

Next

Screen 43

Of the two water conservation options below, which do you prefer?

Select one answer only

- ○ Requiring low-water landscaping in new homes
- ○ Promoting voluntary water conservation through education and incentives

Next

Screen 44

Of the two water recycling options below, which do you prefer? Note that because new piping is necessary for outdoor irrigation and industrial uses, expanding water recycling for outdoor irrigation and industrial uses costs three times as much as expanding water recycling to replenish reservoir supplies.

Select one answer only

- ○ Expanding water recycling to replenish groundwater reservoir supplies
- ○ Expanding water recycling for outdoor irrigation and industrial uses

Next

Screen 45

Thinking about this topic, do you have any comments you would like to share?

Any comments welcome!

Next

Screen 46

Thank you for completing this survey. We have successfully received your responses.

## C.2 Long Beach

# Value of Water Supply Reliability Survey Instrument: Long Beach Version

Screen shots from the Survey Instrument are provided below.

Screen 1

**Your Views on Issues in Southern California**

We are faced with many issues in Southern California, none of which can be solved easily or inexpensively. Below is a list of some of these issues. Some of them may be important to you personally, others may not be important to you personally. How important are the following issues to you?

Select one answer from each row in the grid

| **Issues in Southern California** | Not Important At All | Slightly Important | Moderately Important | Very Important | Extremely Important |
|---|---|---|---|---|---|
| Improving local libraries | ○ | ○ | ○ | ○ | ○ |
| Improving education in public schools | ○ | ○ | ○ | ○ | ○ |
| Reducing taxes | ○ | ○ | ○ | ○ | ○ |
| Increasing water supplies | ○ | ○ | ○ | ○ | ○ |
| Helping farmers increase their incomes | ○ | ○ | ○ | ○ | ○ |
| Reducing crime | ○ | ○ | ○ | ○ | ○ |

Screen 2

This survey focuses on issues related to water in the Long Beach area.

Decisions are being made now that will affect the amount of water we have available in the future. Southern California area water suppliers are interested in your views and opinions to help inform them as they make these decisions.

Next

Screen 3

How long have you lived in Long Beach?

Select one answer only

- ○ Less than 1 year
- ○ 1-2 years
- ○ 3-5 years
- ○ 6-10 years
- ○ More than 10 years

Next

Screen 4

How would you rate your local water supplier's performance in the following areas?

Select one answer from each row in the grid

| **Area** | Not good at all | Slightly good | Moderately good | Very good | Extremely good |
|---|---|---|---|---|---|
| Making sure you have enough water | ○ | ○ | ○ | ○ | ○ |
| Providing safe and healthy drinking water | ○ | ○ | ○ | ○ | ○ |
| Providing good tasting drinking water | ○ | ○ | ○ | ○ | ○ |
| Promoting water conservation | ○ | ○ | ○ | ○ | ○ |

Next

Screen 5

What type of residence do you live in?

Select one answer only

- ○ Home with its own yard
- ○ Townhouse or condominium with its own yard
- ○ Townhouse or condominium without its own yard
- ○ Apartment

Next

Screen 6[9]

Does your yard need regular watering to maintain either a lawn, garden area, or both?

Select one answer only

- ○ Yes
- ○ No

Next

5. [9]. Screen 6 reflects the choice made in Screen 5.

Screen 7

Do you use or enjoy public parks, athletic fields, or other public green spaces that rely on outdoor watering?

Select one answer only

- ○ Yes
- ○ No

Next

Screen 8

Who pays your water bill?

Select one answer only

- ○ My household pays its own water bill
- ○ My landlord pays the water bill
- ○ My water bill is part of my HOA fees
- ○ Other specify: ________
- ○ I don't know how my water bill is paid

Next

Screen 9

The next few screens will provide information about the sources and amount of water used in Long Beach.

Next

**Current Water Use**

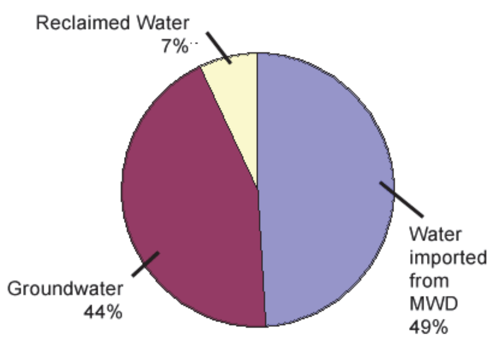
The Long Beach Water Department (LBWD) serves close to half a million people. LBWD has three major sources of water supply:

- ***Treated imported water purchased from the Metropolitan Water District (MWD).*** MWD is the nation's largest water supplier, and its mission is to provide water to 26 cities and water districts throughout Southern California. MWD imports this water from the Colorado River, and from the Northern California Bay Delta Region. Examples of communities that receive imported water from MWD include Los Angeles, Riverside, San Diego, and Long Beach. Roughly half of Long Beach's water is imported and acquired from MWD.
- **What is imported water?**
- ***High-quality local groundwater, extracted and treated by LBWD.*** Groundwater is water that has found its way underground, where it is naturally filtered and stored in the spaces found in the underground environment. The groundwater used by LBWD originates in the San Gabriel Mountains, and travels down the San Gabriel River drainage area, slowly making its way underground along its path to the City. LBWD extracts the groundwater from wells that are greater than 1,000 feet deep. This groundwater supplies about 44% of Long Beach's water needs.
- **What is groundwater?**
- ***Recycled water.*** Recycled water is highly treated wastewater, which is provided to Long Beach by the Los Angeles County Sanitation District. LBWD then distributes this recycled water through a special piping network to locations where it can be safely used for outdoor irrigation and industrial purposes.
- **What is recycled water?**

Screen 10

The pie chart below shows the percentage of LBWD water that comes from these various sources.

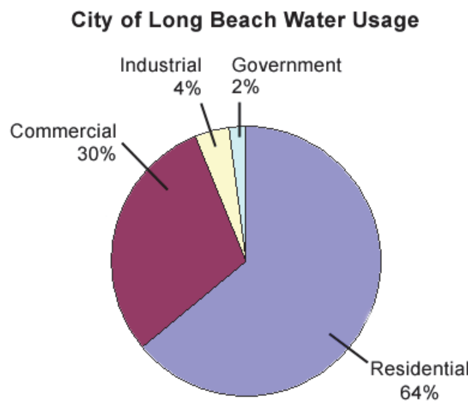
**City of Long Beach Water Supply Sources**




Next

## Screen 11

LBWD provides close to 21 billion gallons of water each year for a variety of different users. The pie chart below shows how much water is used for residential, government, commercial, and industrial purposes. About two-thirds (64%) of water provided by LBWD goes to residential customers.




Next

## Screen 12

The actual amount of water any one household uses depends on:

- The number of people who live in the house;
- What type of home it is, such as houses with their own yards, townhomes, condominiums, or apartments; and
- The amount and type of outdoor landscaping.

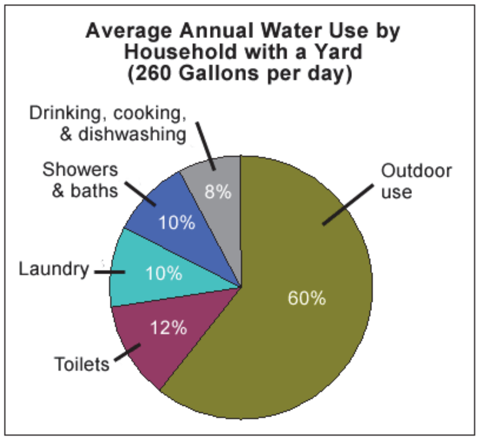
In the Long Beach area, the typical household with its own yard uses 260 gallons of water per day, on average, or about 95,000 gallons per year. Most of this water is used during the summer months for watering lawns and gardens, washing cars, and other outdoor activities.

Households that do not have yards use about 180 gallons of water per day, on average, or about 66,000 gallons per year.

Next

## Screen 13

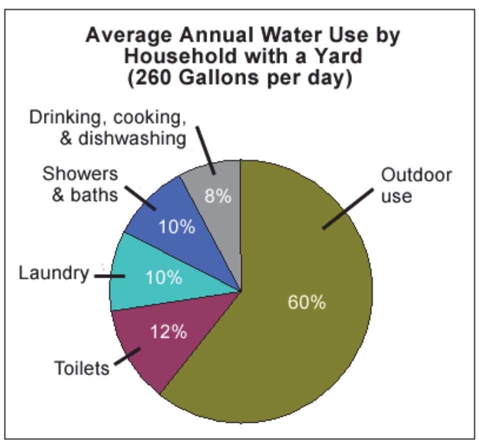
The pie chart below shows how an average household with its own yard uses water throughout the year.




Next

## Screen 14

In thinking about how your household uses water compared to the averages presented in the pie chart, does your household use more, less, or about the same amount of water for <u>outdoor</u> use?




Select one answer only

- ○ More
- ○ Less
- ○ About the same

Next

**CURRENT SUPPLIES WILL NOT MEET FUTURE DEMAND**

The goal of water suppliers is to match available water supplies with demand by taking into account river flow, groundwater levels, reservoir storage, climate, customer demand, and population estimates. This helps to ensure that there will be an adequate supply of clean water in the future.

Even after accounting for savings associated with the existing and planned water conservation activities, we expect water demands to increase in the Long Beach area over the next 20 years. Growing demands, coupled with uncertainty over future rainfall, river levels, and groundwater availability, means that water demands will periodically exceed available water supply in several of the next 20 years. These factors will affect water supplies in all Southern California communities.

The reliability of imported surface water will also be an issue for communities in Southern California (including Long Beach), which largely rely on water imported by MWD:

- In recent years, the amount of water California has imported from the Colorado River has been scaled back by more than 50%. This is due to long-term drought in the Colorado River basin and the fact that California is no longer allowed to use more than its allocated share of Colorado River water.
- Water imported from Northern California has also been limited due to a number of factors, including reduced snow melt, less river water flowing into the Bay Delta, and increased demands from competing water users. In recent years, there also have been court orders that have significantly limited extraction of water from the Bay Delta in order to protect endangered fish.

Screen 15

The availability of imported water is expected to continue to decrease over the next 20 years.

Next

Screen 16

To achieve the goal of ensuring an adequate supply of clean water, LBWD and other regional water suppliers are considering options to make sure that enough water is available in the future. For this reason, LBWD and other water planners in the region are interested in your views on whether some options for avoiding future water shortages should be taken.

Water suppliers do not want to implement new options unless people are willing to pay for them. One way to find out about this is to give people like you information about possible new options, so that you can make up your own mind about them.

Some people think the options they are asked about are not needed; others think they are. We want to get the opinions of all kinds of people.

Next

Screen 17

**Methods to Address Current Water Shortages**

In Long Beach, in addition to voluntary water conservation measures, there are some water use rules that are always in place. These permanent water use restrictions include limitations on outdoor landscape watering. For example, under the permanent water use restrictions:

- Landscape irrigation is limited to 15 minutes per area on Monday, Thursday, and Saturday, after 4:00 p.m. and before 9:00 a.m.
- Water is not allowed to run off irrigated landscape areas onto sidewalks and streets.
- Operating a fountain or similar structure that does not recirculate the water is not allowed.
- All water leaks are required to be fixed in a timely manner.

Next

Screen 18

When there is not enough water to meet demand, additional mandatory water use restrictions become necessary, and they can have significant effects on residents, local businesses, and public parks.

To address water shortages, LBWD currently has two stages of mandatory water use restrictions that can be applied in addition to the permanent water use restrictions that are always in place. The stage selected depends on the severity of water shortages:

**Stage 1 Restrictions.** In addition to the permanent water use restrictions described above, under Stage 1 water use restrictions:

- Landscape watering is only allowed two days per week (Mondays and Thursdays after 4:00 p.m. and before 9:00 a.m.), year-round.
- Filling residential swimming pools and spas with drinking water is not allowed.

**Stage 2 Restrictions.** In addition to the permanent water use restrictions described above, under Stage 2 water use restrictions:

- Most outdoor water use would not be allowed
- Additional water use restrictions may be put in place by the Long Beach Water Board as necessary

Next

Screen 19

Stage 1 restrictions can lead to brown lawns and temporary damage to landscaping for households and public parks.

- Lawns and landscaping can recover if these restrictions are needed for only one year.
- If water shortages require Stage 1 restrictions multiple years in a row, this can lead to dead lawns and landscaping for households and public parks.
- Dead lawns and landscaping would require replacement or conversion to low-water use landscaping (e.g., xeriscape).
- Lawns and public parks irrigated with recycled water would not be impacted because they are not subject to Stage 1 restrictions.

Stage 2 restrictions can lead to dead lawns and landscaping for households and public parks after only one year. Lawns and public parks irrigated with recycled water would not be impacted because they are not subject to Stage 2 restrictions.

Next

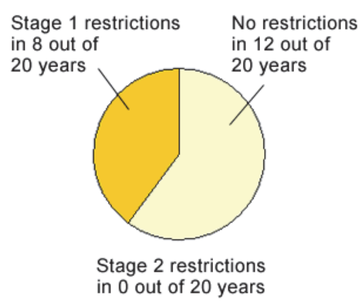
LBWD Stage 1 and Stage 2 water use restrictions are in addition to the permanent water use restrictions that are in place year-round. Stage 1 and Stage 2 water use restrictions are put in place if water shortages become severe or prolonged. Restrictions typically remain in place over a period of several months (e.g., over the summer), and can be lifted by LBWD as the severity of a water shortage is reduced.

In Long Beach, water use restrictions have tended to occur with the following frequencies over the past 20 years:

- Stage 1 restrictions have been needed in 8 of the past 20 years.
- Stage 2 restrictions have not been needed in the last 20 years.

Screen 20

The pie chart below shows how often the different water use restrictions have been in place in this region over the last 20 years.




Next

Screen 21

**Water Suppliers Need to Identify a Water Supply Strategy**

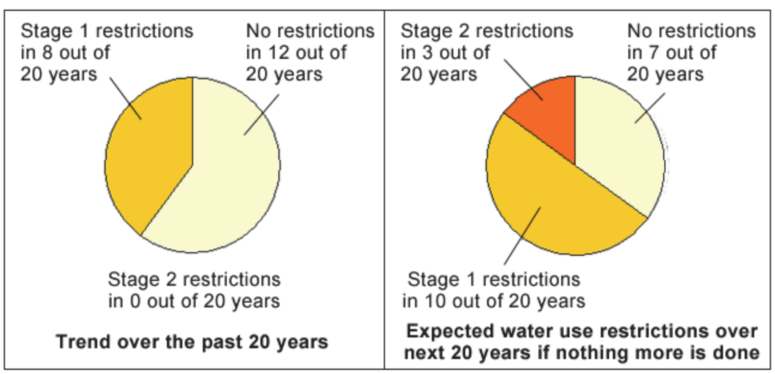
Developing new water supplies can help reduce the frequency and severity of future water shortages. Long Beach and other regional water suppliers are developing a Long-Term Reliable Water Supply Strategy to evaluate how much, if any, additional water supplies should be developed to meet future needs.

While additional water supplies are not mandatory, without new supplies, water use restrictions are expected to become more severe and frequent in the future.

Next

The two pie charts below compare the frequency of water use restrictions in the past with expected restrictions that will be needed in the future if no new water supplies are developed.

- The pie chart on the left shows that Stage 1 restrictions have been needed 8 out of the past 20 years. Stage 2 restrictions have not yet been required. This is the same chart you saw on a previous screen.
- The pie chart on the right is a projection of what the future will be like if no new water supplies are developed. It shows that Stage 1 restrictions are likely to be more frequent in the future than in the past, and that Stage 2 restrictions will be needed in 3 years out of 20 if no actions are taken to develop new water supplies.




Screen 22

Next

Screen 23

**Your Opinion on How Much Should be Done to Increase Future Water Supplies**

The more water supplies that are developed to meet future needs, the more you will have to pay for water in the future. These costs would be passed on to you through your monthly water bill, increased HOA fees, or rent.

Water suppliers do not want to develop new water supplies unless people like you are willing to pay for them. For this reason, they are trying to balance the amount of water supplies in the future against the costs you would face.

On the next three screens, you will have an opportunity to provide your views on reducing the severity of future water use restrictions based on six alternative water supply plans. In later sections, you can provide your opinions on different options for how additional future water supplies, if any, should be developed.

Next

In the table below, you are presented with expected levels of future water use restrictions given different future water supply plans. The table also shows the increased costs to you under each plan.

The first row uses pie charts to show the frequency of different stages of water use restrictions in the next 20 years given different levels of available water supply.

Under the No Additional Actions column, aside from the permanent water use restrictions that are always in place, no additional restrictions will be needed in 7 of the next 20 years. Stage 1 water use restrictions will be in place 10 of the next 20 years, and Stage 2 restrictions will be in place in 3 of the next 20 years.

The exact timing and length of future restrictions is unknown, but it is likely that restrictions would be in place for multiple years in a row (e.g., two seasons of Stage 1 restrictions may be followed by a year of Stage 2 restrictions). This is because drought periods often last 2 or 3 years in a row, and may be followed by one or more years in a row that are wetter. Over the past 20 years, Stage 1 restrictions have occurred in 8 years, and there have been no Stage 2 restrictions.

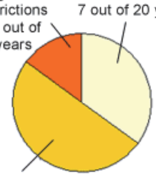
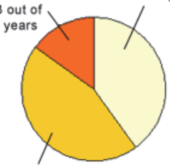
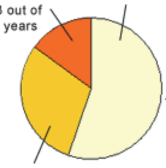
If you would like to be reminded of the permanent water use restrictions, and Stage 1 and Stage 2 restrictions, please click the button on the right. More Info

Water Supply Plans B and C both increase water supplies and have different levels of restrictions over the next 20 years. The second row of the table shows the increase in your water cost under each plan. Under the No Additional Actions column, your monthly water costs will increase by $1, which means that you will pay an additional $12 per year.

If you choose to spend money for a plan that increases water supplies, that money will not be available for you to buy other things.

Please review the table and check the box under the plan you most prefer.

Screen 24

| | No Additional Actions | Plan B | Plan C |
|---|---|---|---|
| Available water supply such that water use restrictions in the next 20 years will be: | Stage 2 restrictions in 3 out of 20 years<br>No restrictions in 7 out of 20 years<br><br>Stage 1 restrictions in 10 out of 20 years | Stage 2 restrictions in 3 out of 20 years<br>No restrictions in 8 out of 20 years<br><br>Stage 1 restrictions in 9 out of 20 years | Stage 2 restrictions in 3 out of 20 years<br>No restrictions in 11 out of 20 years<br><br>Stage 1 restrictions in 6 out of 20 years |
| Increase in your water cost | $1 per month, which would be $12 per year | $2 per month, which would be $20 per year | $11 per month, which would be $130 per year |
| **Which plan do you prefer?** | ○ | ○ | ○ |

Next

## Screen 25[10]

Please provide a brief comment to help us understand why you chose $2 per month, which would be $20 per year, as your most preferred plan.

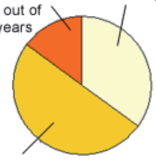
Type in the answer

Next

## Screen 26

This table presents some additional expected future water use restrictions in the next 20 years based on alternative water supply plans, at different costs to you.

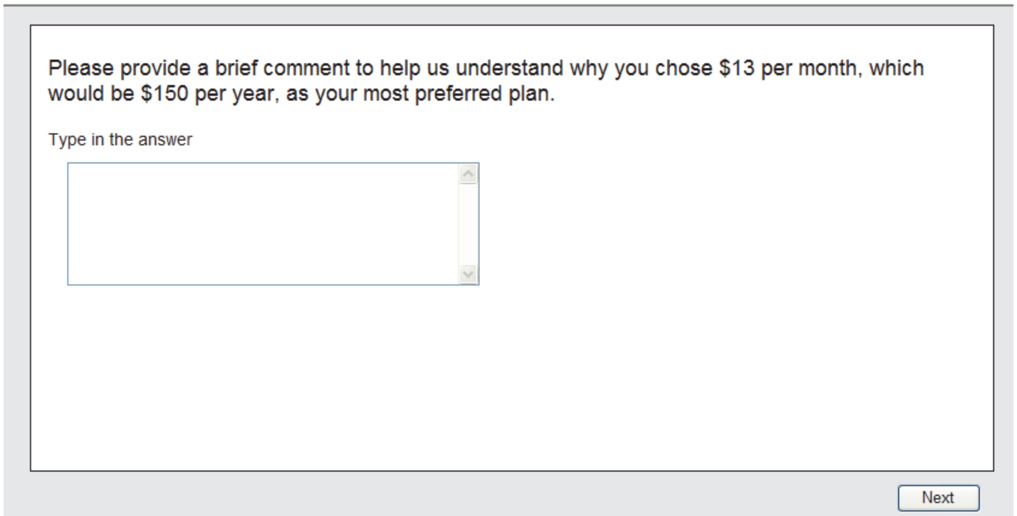
Please review the table and check the box under the plan you most prefer.

| | No Additional Actions | Plan D | Plan E |
|---|---|---|---|
| Available water supply such that water use restrictions in the next 20 years will be: | Stage 2 restrictions in 3 out of 20 years; No restrictions in 7 out of 20 years  Stage 1 restrictions in 10 out of 20 years | Stage 2 restrictions in 2 out of 20 years; No restrictions in 11 out of 20 years  Stage 1 restrictions in 7 out of 20 years | Stage 2 restrictions in 3 out of 20 years; No restrictions in 10 out of 20 years  Stage 1 restrictions in 7 out of 20 years |
| Increase in your water cost | $1 per month, which would be $12 per year | $13 per month, which would be $150 per year | $5 per month, which would be $55 per year |
| **Which plan do you prefer?** | ○ | ○ | ○ |

Next

6. [10]. Screen 25 reflects the choice made in Screen 24.

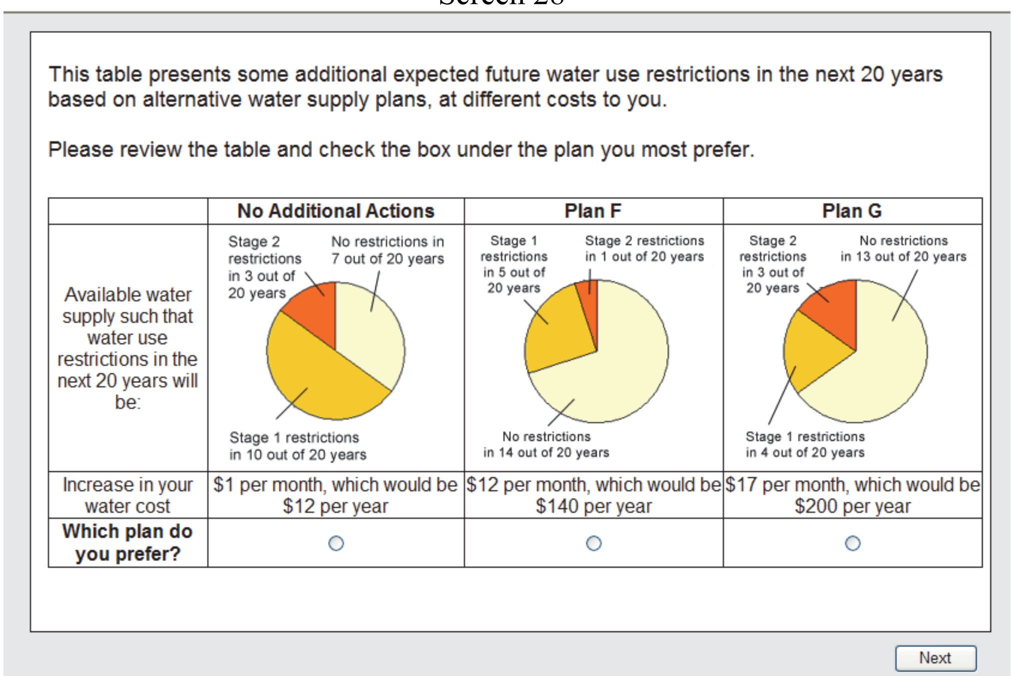
Screen 27[11]


Please provide a brief comment to help us understand why you chose $13 per month, which would be $150 per year, as your most preferred plan.

Type in the answer

Next

Screen 28


This table presents some additional expected future water use restrictions in the next 20 years based on alternative water supply plans, at different costs to you.

Please review the table and check the box under the plan you most prefer.

| | No Additional Actions | Plan F | Plan G |
|---|---|---|---|
| Available water supply such that water use restrictions in the next 20 years will be: | Stage 2 restrictions in 3 out of 20 years; No restrictions in 7 out of 20 years; Stage 1 restrictions in 10 out of 20 years | Stage 1 restrictions in 5 out of 20 years; Stage 2 restrictions in 1 out of 20 years; No restrictions in 14 out of 20 years | Stage 2 restrictions in 3 out of 20 years; No restrictions in 13 out of 20 years; Stage 1 restrictions in 4 out of 20 years |
| Increase in your water cost | $1 per month, which would be $12 per year | $12 per month, which would be $140 per year | $17 per month, which would be $200 per year |
| **Which plan do you prefer?** | ○ | ○ | ○ |

Next

7. [11]. Screen 27 reflects the choice made in Screen 26.

Screen 29[12]

Please provide a brief comment to help us understand why you chose $12 per month, which would be $140 per year, as your most preferred plan.

Type in the answer

Next

Screen 30

**Your Opinion on How We Should Increase Future Water Supplies**

LBWD is evaluating different options to increase the amount of water available in the future to reduce water use shortages.

While no actions are perfect, there are opportunities to improve the reliability of future water supplies and reduce the frequency and severity of future water use restrictions.

The options that are being considered include:

- Increasing groundwater use **What is groundwater?**
- Importing additional water to the region **What is imported water?**
- Increasing water storage
- Transferring water from agricultural uses
- Increasing the amount of water conservation
- Increasing the use of recycled water **What is recycled water?**
- Adding desalinated water

The next few screens provide more details on each of these options.

Next

8. [12]. Screen 29 reflects the choice made in Screen 28.

Screen 31

**Transferring water from agricultural uses**

Improvements in how agriculture uses water could be made, which would reduce the amount of water that is needed by farmers. This saved water could be transferred to the Long Beach area for residential and business uses. Water could be saved by having LBWD:

- Pay for the use of improved agricultural irrigation systems that can reduce the amount of water lost to evaporation.
- Pay the extra cost for farmers to use new plant breeds that can provide the same harvest with less water.
- Purchase agricultural land and take it out of agricultural production.

Next

Screen 32

**Increasing underground water storage**

Water storage could be expanded by purchasing additional imported Bay-Delta water from MWD in years when Northern California Bay-Delta waters are more plentiful, and storing it underground in the local groundwater basin, where it could be extracted and used locally in dry years.

Long Beach could also increase the amount of recycled water it currently acquires from Los Angeles County's Long Beach Reclamation Plant, and store it underground in the local groundwater basin. This would help replenish groundwater levels and could later be extracted, re-purified, and used for tap water and other uses.

Next

Screen 33

**Increasing the amount of water conservation**

A lot of individual water conservation measures have already been taken by residents and businesses in Long Beach. However, there are still opportunities for additional conservation measures, especially for reducing outdoor water use by giving up lawns at homes, athletic fields, and public parks. Increased water conservation actions could include:

- Rebates for water saving appliances
- Rebates for converting to low-water use landscaping (e.g., xeriscape)
- Mandatory low-water landscaping for new homes.

Next

Screen 34

**Increasing groundwater use**

Groundwater is water that collects or flows beneath the Earth's surface, filling the porous spaces in soil, sediment, and rocks. Groundwater originates from rain and from melting snow and ice and is the source of water for aquifers, springs, and wells. High-quality groundwater from both local and non-local sources can be used for drinking water supplies.

Use of additional local groundwater supplies is limited by Court-imposed pumping restrictions, which are designed to ensure the water is not over-pumped and depleted. Additional local groundwater use would only be possible if additional water is used to replenish the local groundwater system. Groundwater replenishment could include pumping reclaimed water into the groundwater. In wet years, imported water could also be used to replenish the local groundwater basin.

Use of non-local groundwater supplies would require acquiring rights to that non-local water, and installing additional pipelines and pumps to transfer the water to Long Beach. This approach would also have increased energy costs associated with moving the water to the Long Beach area.

Next

Screen 35

**Increasing the use of recycled water**

About 6% of the LBWD's current water supply is made up of highly purified recycled water from Los Angeles County's Long Beach Reclamation Plant. LBWD would like to increase the amount of reclaimed water it receives from this facility, and distribute it for suitable uses throughout the city. After it is purified to meet applicable standards, recycled water can be used:

- For watering public landscape areas, parks, and golf courses. It might also be available for watering some household yards.
- For some industrial processes, such as cooling in power plants.
- To replenish the local groundwater basin. This stored water could later be extracted, re-purified, and used for tap water.

The use of recycled water is not impacted by external factors such as drought or climate change. Recycled water is therefore considered a very reliable source of water supply.

Next

Screen 36

**Importing additional water into the region**

Additional water supplies could be created by importing more water from outside of Long Beach ( e.g., purchasing more Bay-Delta water from MWD). Importing additional water from outside Long Beach may have some negative consequences. Removing water from distant rivers and lakes could:

- Harm ecosystems and limit recreational opportunities in Northern California
- Limit the amount of water available to people living near the rivers from which the water is exported to MWD
- Increase energy costs associated with transferring the water to Long Beach

In addition, imported water could become less available in the future, due to court rulings, regulations, droughts, or earthquakes that might disrupt the long import supply canals and pipelines

Next

Screen 37

**Adding desalinated water**

LBWD is currently developing the Long Beach Seawater Desalination Project, which will convert ocean water to drinking water. It will use well established, tested, and effective water treatment technologies (e.g., reverse osmosis membranes). Desalination has been used extensively in other parts of the world and is beginning to be implemented more extensively in the United States. Desalination provides a local source of supply that is reliable and not impacted by weather or climate.

Desalination requires a large amount of energy and can be relatively expensive. However, the cost of desalination relative to the development of other new water supply sources is becoming more favorable. Developments in technology have also decreased costs.

The environmental impacts of desalination can be a concern. When ocean water is drawn into the desalination plant, fish and other species can get trapped against the intake screens. To avoid this problem, LBWD has designed and tested a path-breaking beach sand water intake system that will not harm fish (because it eliminates the need for an ocean intake pipe).

The disposal of the salt and other compounds that are extracted from the seawater can be a concern. However, the potential Long Beach desal facility will be designed such that the salts removed from the seawater are safely mixed back into the ocean.

LBWD is planning to develop the desalination project in an aesthetically pleasing manner that will not impact local beach areas. The desal treatment plant is planned to be located inland, away from the City's beaches.

Next

**Your Opinion on How We Should Meet Future Water Needs**

In the table below, you are presented with different options that water suppliers could undertake to improve the future water supply reliability.

Please rank your top 5 options for increasing our future water supply according to your personal views. If you want to rank more, please feel free to do so.

Put a "1" for the option you would first like to see done to reduce future water shortages, a "2" next to your second most preferred option, and so on until you have ranked at least 5 options.

Type in the answer into each cell in the grid

Screen 38

| | |
|---|---|
| Requiring low water landscaping (e.g., xeriscape) in new homes and redevelopment projects | |
| Increasing available supplies of water by expanding the import and use of non-local groundwater (i.e., water found underground and accessed by wells at locations some distance from Long Beach, and then pumped to the City) | |
| Expanding the use of reclaimed water for outdoor irrigation and industrial uses | |
| Using highly purified reclaimed water to replenish the local groundwater supply, allowing greater use of local groundwater | |
| Increasing available supplies in dry years by acquiring more imported MWD water in wet years, and storing it underground for local use in dry years | |
| Promoting more voluntary water conservation through additional education and incentives (e.g., rebates to convert to low water landscaping and water efficient appliances) | |
| Increasing the amount of water that is imported from Northern California (from the Bay-Delta) or the Colorado River, and purchased from the Metropolitan Water District (MWD) | |
| Increasing available supplies of water by transferring more water from agricultural uses in the State to Long Beach or MWD | |
| Investing in desalination facilities to convert ocean waters into part of the local potable supply | |
| Increasing the price of water to residential, commercial, and industrial users so that they will use less | |

Next

## Screen 39[13]

**Of these five options, which do you like the <u>least</u>?**

Select one answer only

- ○ Increasing the amount of water that is imported from Northern California (from the Bay-Delta) or the Colorado River, and purchased from the Metropolitan Water District (MWD)
- ○ Increasing available supplies of water by transferring more water from agricultural uses in the State to Long Beach or MWD
- ○ Increasing the price of water to residential, commercial, and industrial users so that they will use less
- ○ Increasing available supplies of water by expanding the import and use of non-local groundwater (i.e., water found underground and accessed by wells at locations some distance from Long Beach, and then pumped to the City)
- ○ Increasing available supplies in dry years by acquiring more imported MWD water in wet years, and storing it underground for local use in dry years

Next

## Screen 40

**Does it Matter How We Reduce Future Water Shortages?**

There are different ways that water suppliers can provide the same amount of water supply in the future. The next few questions ask you to choose among options that could be implemented to reduce the frequency of water shortages in the future. For each of the following questions, please indicate which option you prefer.

Next

9. [13]. Screen 39 reflects the choices made in Screen 38.

## Screen 41

**Of the two underground water storage options below, which do you prefer?**

Select one answer only

- ○ Increasing underground storage of imported water in wet years
- ○ Increasing underground storage of recycled water

Next

## Screen 42

**Of the two groundwater water options below, which do you prefer?**

Select one answer only

- ○ Increasing use of local groundwater sources through replenishing the basin
- ○ Increasing use of non-local groundwater sources and pumping the water to Long Beach

Next

## Screen 43

**Of the two water transfer and import options below, which do you prefer?**

Select one answer only

- ○ Increasing water transfers from agriculture
- ○ Increasing water imports from MWD

Next

Screen 44

Of the two water conservation options below, which do you prefer?

Select one answer only

- ○ Requiring low-water landscaping in new homes
- ○ Promoting additional voluntary water conservation through education and incentives

Next

Screen 45

Of the two water recycling options below, which do you prefer? Note that because new piping is necessary for outdoor irrigation and industrial uses, expanding water recycling for outdoor irrigation and industrial uses costs three times as much as expanding water recycling to replenish groundwater supplies.

Select one answer only

- ○ Expanding water recycling to replenish local groundwater supplies
- ○ Expanding water recycling for outdoor irrigation and industrial uses

Next

Screen 46

Thinking about this topic, do you have any comments you would like to share?

Any comments welcome!

Next

Screen 47

Thank you for completing this survey. We have successfully received your responses.

## C.3 Orlando

# Value of Water Supply Reliability Survey Instrument: Orlando Version

Screen shots from the Survey Instrument are provided below.

**Your Views on Issues in Central Florida**

We are faced with many issues in Central Florida, none of which can be solved easily or inexpensively. Below is a list of some of these issues. Some of them may be important to you personally, others may not be important to you personally. How important are the following issues to you?

Select one answer from each row in the grid

| Issues in Central Florida | Not Important At All | Slightly Important | Moderately Important | Very Important | Extremely Important |
|---|---|---|---|---|---|
| Increasing water supplies | ○ | ○ | ○ | ○ | ○ |
| Improving education in public schools | ○ | ○ | ○ | ○ | ○ |
| Helping farmers increase their incomes | ○ | ○ | ○ | ○ | ○ |
| Improving local libraries | ○ | ○ | ○ | ○ | ○ |
| Reducing crime | ○ | ○ | ○ | ○ | ○ |
| Reducing taxes | ○ | ○ | ○ | ○ | ○ |

Next

Screen 1

This survey focuses on issues related to water in the Orlando area.

Decisions are being made now that will affect the amount of water we have available in the future. Central Florida area water suppliers are interested in your views and opinions to help inform them as they make these decisions.

Next

Screen 2

How long have you lived in Orlando?

Select one answer only

- ○ Less than 1 year
- ○ 1-2 years
- ○ 3-5 years
- ○ 6-10 years
- ○ More than 10 years

Next

Screen 3

How would you rate your local water supplier's performance in the following areas?

Select one answer from each row in the grid

| Area | Not good at all | Slightly good | Moderately good | Very good | Extremely good |
|---|---|---|---|---|---|
| Making sure you have enough water | ○ | ○ | ○ | ○ | ○ |
| Providing safe and healthy drinking water | ○ | ○ | ○ | ○ | ○ |
| Providing good tasting drinking water | ○ | ○ | ○ | ○ | ○ |
| Promoting water conservation | ○ | ○ | ○ | ○ | ○ |

Next

Screen 4

Screen 5

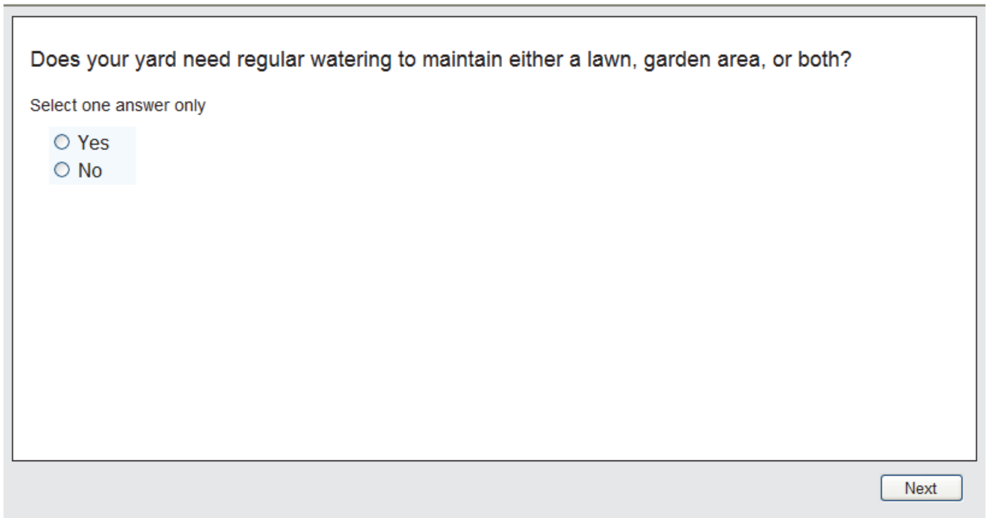
What type of residence do you live in?

Select one answer only

- ○ Home with its own yard
- ○ Townhouse or condominium with its own yard
- ○ Townhouse or condominium without its own yard
- ○ Apartment

Next

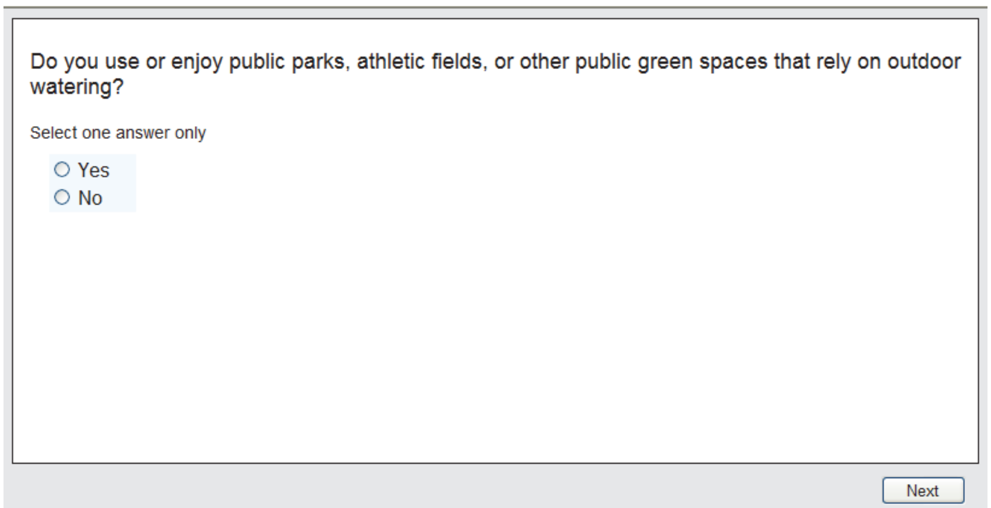
Screen 6[14]


Does your yard need regular watering to maintain either a lawn, garden area, or both?

Select one answer only

- Yes
- No

Next


Do you use or enjoy public parks, athletic fields, or other public green spaces that rely on outdoor watering?

Select one answer only

- Yes
- No

Next

Screen 7

10. [14]. Screen 6 reflects the choice made in Screen 5.

Who pays your water bill?

Select one answer only

- ○ My household pays its own water bill
- ○ My landlord pays the water bill
- ○ My water bill is part of my HOA fees
- ○ Other specify: ________
- ○ I don't know how my water bill is paid

Next

Screen 8

The next few screens provide information about the sources and amount of water used in Orlando.

Next

Screen 9

Screen 10

**Current Water Use**

Groundwater from the Floridan Aquifer is the primary source of water supply in your area. Groundwater is water that has found its way underground, where it is naturally filtered and stored in the spaces found in the underground environment. The underground environment is known as an aquifer if it can yield a usable quantity of water. The groundwater used by your water utility is located a quarter of a mile below the earth's surface. This deep water supply is protected from contaminants, pollutants, and bacteria, and requires little purification treatment.

**What is groundwater?**

Approximately 10% of the water used in your area is recycled water. Recycled water is highly treated wastewater. This recycled water is transported through a special piping network to locations where it can be safely used for outdoor irrigation and industrial purposes. In the Orlando area, recycled water is used to irrigate residential lawns and landscapes, and golf courses.

**What is recycled water?**

Next

Screen 11

Your water utility provides 25 billion gallons of water each year for a variety of different users. About half of the water (50%) supplied by your local water utility goes to residential customers. The other half is used for commercial, industrial, and public use (e.g., governmental) purposes.

Next

Screen 12

The actual amount of water any one household uses depends on:

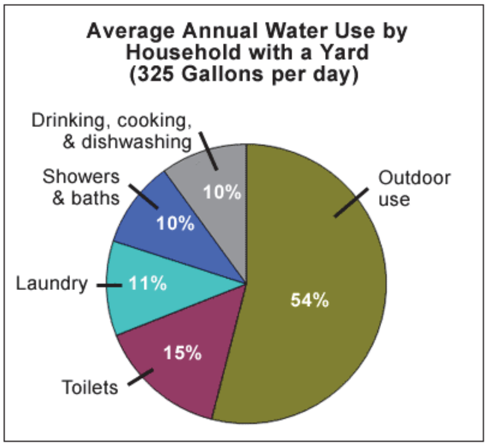
- The number of people who live in the house;
- What type of home it is, such as houses with their own yards, townhomes, condominiums, or apartments; and
- The amount and type of outdoor landscaping.

In the Orlando area, the typical household with its own yard uses about 325 gallons of water per day, on average, or about 119,000 gallons per year. About 54 percent of this water is used for watering lawns and gardens. Households that do not have yards use about 150 gallons of water per day, on average, or about 55,000 gallons per year.

Next

Screen 13

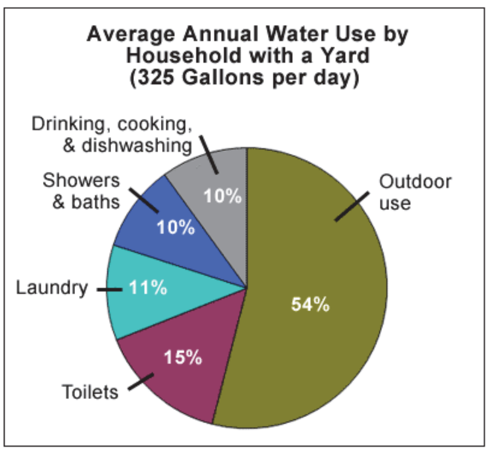
The pie chart below shows how an average household with its own yard uses water throughout the year.




Next

Screen 14

In thinking about how your household uses water compared to the averages presented in the pie chart, does your household use more, less, or about the same amount of water for <u>outdoor</u> use?




Select one answer only

- ○ More
- ○ Less
- ○ About the same

Next

Screen 15

**CURRENT SUPPLIES WILL NOT MEET FUTURE DEMAND**

The goal of water suppliers is to provide the highest quality water at a reasonable cost and in sufficient quantity to meet customer needs. To meet this goal, water suppliers in your area match available water supplies with demand by taking into account groundwater levels, reservoir storage, climate, customer demand, and population estimates. This helps to ensure that there will be an adequate supply of clean water in the future.

Even after accounting for savings associated with the existing and planned water conservation activities, we expect that water demands in the Orlando area will increase over the next 20 years. Growing demands, coupled with uncertainty over future rainfall and groundwater availability, means that water demands are expected to periodically exceed available water supply in several of the next 20 years. These factors will affect water supplies in many Florida communities.

In addition, using too much groundwater in the future for drinking water supplies may result in environmental impacts, such as drying out wetlands, reducing spring flows, lowering lake and ground water levels and degrading groundwater quality. Florida's regulatory program works to ensure these types of impacts do not occur.

Next

Screen 16

To achieve the goal of ensuring an adequate supply of clean water, water suppliers in the Orlando region are considering options to make sure that enough water is available in the future. For this reason, water suppliers in the region are interested in your views on whether some options for avoiding future water shortages should be taken.

Water suppliers do not want to implement new options unless people are willing to pay for them. One way to find out about this is to give people like you information about possible new options, so that you can make up your own mind about them.

Some people think the options they are asked about are not needed; others think they are. We want to get the opinions of all kinds of people.

Next

## Screen 17

**Methods to Address Current Water Shortages**

In Orlando, in addition to voluntary water conservation measures, there are some water conservation requirements that are always in place. These water conservation requirements limit the days and times when households may water their lawns. For example:

- Irrigation is prohibited between 10 a.m. and 4 p.m.
- From March through November, irrigation is limited to two days per week on scheduled days.
- From November through March, irrigation is limited to one day per week on scheduled days.
- Irrigation is limited to ¾ inch of water per irrigation day and to no more than one hour per irrigated area per irrigation day.
- Persons irrigating with an automatic lawn irrigation system installed after May 1991 are required to install, maintain and operate a rain sensor device.
- The use of recycled water and irrigation using a low-volume system (e.g., micro-spray, micro-jet, drip or bubbler irrigation) is allowed anytime.
- Irrigation of *new* landscape is allowed at any time of day on any day for the initial 30 days and every other day for the next 30 days.

Next

When there is not enough water to meet demand, mandatory water use restrictions may become necessary, and they can have significant effects on residents, local businesses, and public parks. Depending on the severity of the water supply shortage, Stage 1 or Stage 2 water use restrictions may be implemented.

**Stage 1 Restrictions** In addition to the permanent water use restrictions described on the previous screen, under Stage 1 water use restrictions:

- All water users are required to test and repair their irrigation system to address broken pipes and other leaks, damaged or tilted sprinkler heads, and other sources of water waste.
- Lawn and landscape irrigation at residences, common areas, golf courses, and parks is restricted to one day per week on designated days, between the hours of 6 pm and 9 am all year long.
- Irrigation of child playgrounds and play areas for sports is allowed any day from the hours of 6 p.m. to 9 a.m.
- Cisterns, hand-watering using a hose with a trigger nozzle, and low-volume irrigation systems – such as drip, bubble and micro-jet systems that apply water directly to plant root zones – may be used at any time, although voluntary reductions are encouraged.
- Irrigation with recycled water is exempt from all water use restrictions.
- The use of water for fountains and other decorative displays is prohibited.
- All water users including residences, golf courses, industrial and commercial businesses, and farmers must reduce their water use by 15 percent from the most recent previous year that water shortage restrictions were not in effect.
- Additional water use restrictions may be put by in place by your local water utility as necessary.

Screen 18

**Stage 2 Restrictions** Stage 2 restrictions are in addition to all Stage 1 restrictions. Under Stage 2 restrictions:

- Lawn and landscape irrigation at residences, common areas, golf courses, schools, and parks is prohibited.
- Irrigation of child playgrounds and play areas for sports is allowed one day per week from the hours of 6 pm to 9 a.m.
- Cisterns, hand-watering using a hose with a trigger nozzle, and low-volume irrigation systems may be used at any time to water non-turfgrass landscape, although voluntary reductions are encouraged.
- Irrigation with recycled water is exempt from all water use restrictions.
- Washing or cleaning of non-emergency vehicles is limited to one day per week and must be done using low volume methods. This includes vehicle washing or cleaning at car washes.
- Washing or cleaning of buildings, structures and other outdoor surfaces is prohibited unless necessary to either maintain a warranty, allow for a construction practice, clean up after a public event, or remove mold, mildew and other potentially hazardous material that cannot be removed by mechanical means.
- All water users must reduce their water use by 20 percent from the most recent previous year that water shortage restrictions were not in effect.
- Additional water use restrictions may be put by in place by your local water utility as necessary.

Next

Under Stage 1 restrictions, businesses, households and water utilities will likely incur costs as they make irrigation system repairs and implement additional water conservation activities. Stage 1 restrictions can lead to brown lawns and temporary damage to landscaping for households, golf courses, and public areas.

- Lawns and landscaping can recover if these restrictions are needed for only one summer.
- If water shortages require Stage 1 restrictions multiple years in a row, this can lead to dead lawns and landscaping for households and public parks.
- Dead lawns and landscaping would require replacement or conversion to low water use landscaping (e.g., Florida Friendly landscaping).

Under Stage 1 restrictions, lawns and landscaping irrigated with recycled water or using low-volume irrigation systems would not be impacted because they are not subject to the water restrictions.

Stage 2 restrictions may lead to dead lawns and landscaping for households, golf courses, and public parks after only one year. Irrigation of all turf grass at would be prohibited, with the exception of irrigation of child playgrounds and play areas for sports, which is allowed one day per week.

Dead lawns and landscaping would require replacement. To lessen the extent of dead lawns and landscaping, irrigators may choose to replace dead lawns with low-water use landscaping (e.g., Florida Friendly landscaping), convert their sprinkler systems to low-volume irrigation systems, or install cisterns.

Under Stage 2 restrictions, lawn and landscape irrigated with recycled water would not be impacted because they are not subject to the water restrictions. Irrigators using low-volume irrigation systems would still be able to water their plant beds, shrubs and other non-turfgrass material.

Screen 19

Next

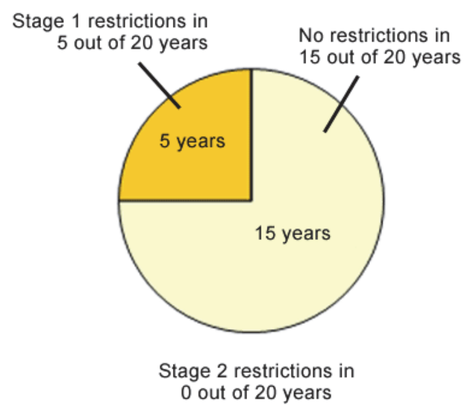
Stage 1 and Stage 2 water use restrictions are put in place by the St. Johns River Water Management District if water shortages become severe or prolonged. Restrictions can remain in place over a period of several months to several years, and can be lifted by the District as the severity of a water shortage is reduced.

In Orlando, water use restrictions have tended to occur with the following frequencies over the past 20 years:

- Stage 1 restrictions have been needed in 5 of the past 20 years.
- Stage 2 restrictions have not been needed in the past 20 years.

The pie chart below shows how often the different water use restrictions have been in place in this region over the last 20 years.

Screen 20




Next

Screen 21

**Water Suppliers Need to Identify a Water Supply Strategy**

Developing new water supplies can help reduce the frequency and severity of future water shortages. Water suppliers in central Florida are developing a Long-Term Reliable Water Supply Strategy to evaluate how much, if any, additional water supplies should be developed to meet future needs.

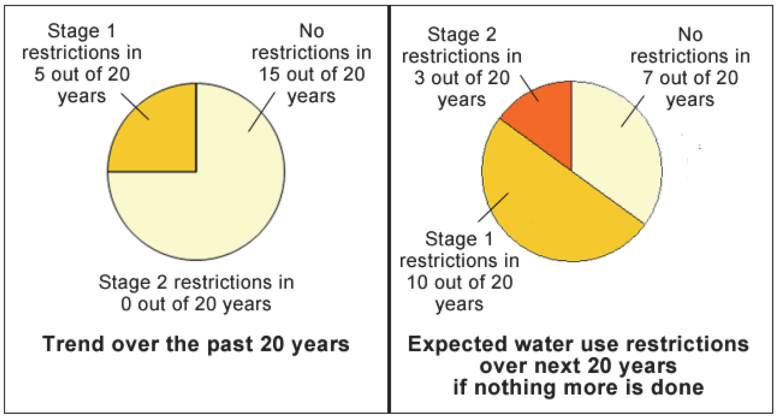
While additional water supplies are not mandatory, without new supplies, water use restrictions are expected to become more severe and frequent in the future.

Next

## Screen 22

The two pie charts below compare the frequency of water use restrictions in the past with restrictions that are expected to be needed in the future if no new water supplies are developed.

- The pie chart on the left shows that Stage 1 restrictions have been needed 5 out of the past 20 years. No restrictions have been needed in 15 of the last 20 years. This is the same chart you saw on a previous screen.
- The pie chart on the right is a projection of what the future will be like if no new water supplies are developed. It shows that Stage 1 restrictions are likely to be more frequent in the future than in the past, and that Stage 2 restrictions will be needed in 3 years out of 20 if no actions are taken to develop new water supplies.




Next

## Screen 23

**Your Opinion on How Much Should be Done to Increase Future Water Supplies**

New water supplies are expected to be more expensive, gallon for gallon, than the existing water supply from the Floridan aquifer. As more expensive water supplies are developed to meet future needs, the more you will have to pay for water in the future. These costs would be passed on to you through your monthly water bill, increased HOA fees, or rent.

Water suppliers do not want to develop new water supplies unless people like you are willing to pay for them. For this reason, they are trying to balance the amount of water supplies in the future against the costs you would face.

On the next three screens, you will have an opportunity to provide your views on reducing the severity of future water use restrictions based on six alternative water supply plans. In later sections, you can provide your opinions on different options for how additional future water supplies, if any, should be developed.

Next

In the table below, you are presented with expected levels of future water use restrictions given different future water supply plans. The table also shows the increased costs to you under each plan.

The first row uses pie charts to show the frequency of different stages of water use restrictions in the next 20 years given different levels of available water supply.

Under the No Additional Actions column, aside from the permanent water conservation requirements that are always in place, no additional restrictions will be needed in 7 of the next 20 years. Stage 1 water use restrictions will be in place 10 of the next 20 years, and Stage 2 restrictions will be in place in 3 of the next 20 years.

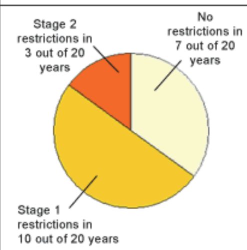
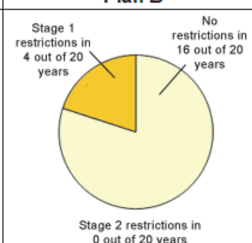
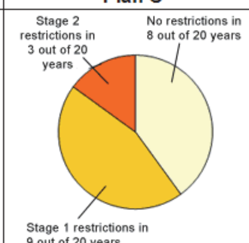
The exact timing and length of future restrictions is unknown, but it is likely that restrictions would be in place for multiple years in a row (e.g., two years of Stage 1 restrictions may be followed by a year of Stage 2 restrictions). This is because drought periods often last 2 or 3 years in a row, and may be followed by one or more years in a row that are wetter. Over the past 20 years, Stage 1 restrictions have occurred in 5 years, and Stage 2 restrictions have not been implemented.

If you would like to be reminded of the permanent water use restrictions, and Stage 1 and Stage 2 restrictions, please click the button on the right. More Info

Water Supply Plans B and C both increase water supplies and have different levels of restrictions over the next 20 years. The second row of the table shows the increase in your water cost under each plan. Under the No Additional Actions column, your monthly water costs will increase by $1, which means that you will pay an additional $12 per year.

If you choose to spend money for a plan that increases water supplies, that money will not be available for you to buy other things. Please review the table and check the box under the plan you most prefer.

Screen 24

| | **No Additional Actions** | **Plan B** | **Plan C** |
|---|---|---|---|
| Available water supply such that water use restrictions in the next 20 years will be: |   |   |   |
| Increase in your water cost | $1 per month, which would be $12 per year | $15 per month, which would be $180 per year | $2 per month, which would be $20 per year |
| **Which plan do you prefer?** | ○ | ○ | ○ |

Next

## Screen 25[15]

Please provide a brief comment to help us understand why you chose $15 per month, which would be $180 per year, as your most preferred plan.

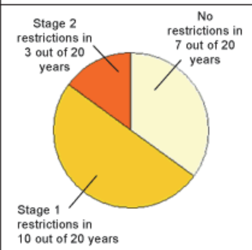
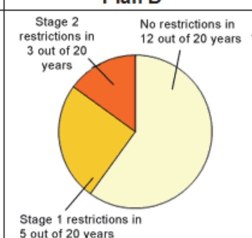
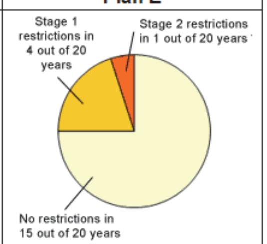
Type in the answer

Next

## Screen 26

This table presents some additional expected future water use restrictions in the next 20 years based on alternative water supply plans, at different costs to you.

Please review the table and check the box under the plan you most prefer.

| | No Additional Actions | Plan D | Plan E |
|---|---|---|---|
| Available water supply such that water use restrictions in the next 20 years will be: |   |   |   |
| Increase in your water cost | $1 per month, which would be $12 per year | $8 per month, which would be $90 per year | $24 per month, which would be $290 per year |
| **Which plan do you prefer?** | ○ | ○ | ○ |

Next

11. [15]. Screen 25 reflects the choice made in Screen 24.

## Screen 27[16]

Please provide a brief comment to help us understand why you chose $8 per month, which would be $90 per year, as your most preferred plan.

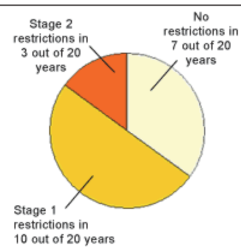
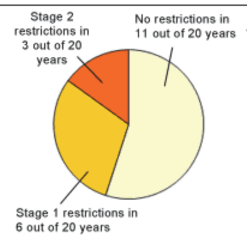
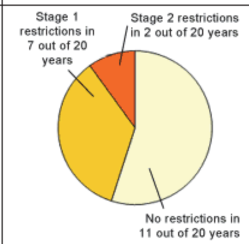
Type in the answer

Next

## Screen 28

This table presents some additional expected future water use restrictions in the next 20 years based on alternative water supply plans, at different costs to you.

Please review the table and check the box under the plan you most prefer.

| | No Additional Actions | Plan F | Plan G |
|---|---|---|---|
| Available water supply such that water use restrictions in the next 20 years will be: |  |  |  |
| Increase in your water cost | $1 per month, which would be $12 per year | $11 per month, which would be $130 per year | $13 per month, which would be $150 per year |
| **Which plan do you prefer?** | ○ | ○ | ○ |

Next

12. [16]. Screen 27 reflects the choice made in Screen 26.

## Screen 29[17]

Please provide a brief comment to help us understand why you chose $11 per month, which would be $130 per year, as your most preferred plan.

Type in the answer

Next

## Screen 30

Your water utility and other utilities in the region are evaluating different options to increase the amount of water available in the future to reduce water shortages.

While no actions are perfect, there are opportunities to improve the reliability of future water supplies and reduce the frequency and severity of future water use restrictions.

The options that are being considered include:

- Increasing use of fresh groundwater **What is groundwater?**
- Using surface water supplies, by diverting water from the St. Johns River to storage reservoirs
- Storing recycled water underground when plentiful and withdrawing the water when needed
- Storing river water imported from the St. Johns River underground when it is plentiful and withdrawing the water when needed
- Increasing the amount of water conservation
- Increasing the use of recycled water **What is recycled water?**
- Adding desalinated seawater from the Atlantic Ocean
- Adding desalinated brackish groundwater from wells near the east coast

The next few screens provide more details on each of these options.

Next

13. [17]. Screen 29 reflects the choice made in Screen 28.

Screen 31

**Diverting water from the St. Johns River to storage reservoirs**

Additional water supplies could be created by diverting and storing surface water from the St. Johns River. However, importing this water may have some negative consequences. Removing water from the river could:

- Harm ecosystems and limit recreational opportunities in the water body from which the water is diverted
- Increase energy costs associated with transferring the water to Orlando
- Increase water treatment costs relative to current groundwater sources

To help offset these potential consequences, the diversion of water from the St. Johns River would be managed so that they do not take too much water from the river in times of low flow. In other words, water diversions would maintain minimum flows and levels - known as MFLs - that have been established by the St. Johns River Water Management District. The purpose of the MFLs is to protect the water resources and ecology of the area. To ensure compliance with MFLs, specific projects can be designed to withdraw water during times of moderate to high flow so that no water is withdrawn during periods of low flow.

Next

Screen 32

**Increasing fresh groundwater use**

Groundwater is water that collects or flows beneath the Earth's surface, filling the porous spaces in soil, sediment, and rocks. Groundwater originates from rain and from melting snow and ice and is the source of water for aquifers, springs, and wells. High-quality groundwater from both local and non-local sources can be used for drinking water supplies. The term "fresh" means that the ground water is not salty.

Use of additional local fresh groundwater supplies is limited by the St. Johns River Water Management District, which manages this water supply to ensure the water is not over-pumped and depleted. Additional local groundwater use would only be possible if additional water is used to replenish the local groundwater system. Groundwater replenishment could include pumping reclaimed water into the groundwater. In wet years, imported water could also be used to replenish the local groundwater basin.

Use of non-local groundwater supplies would require acquiring rights to that non-local water, and installing additional pipelines and pumps to transfer the water to the Orlando region. This approach would also have increased energy costs associated with transporting the water.

Next

Screen 33

**Adding desalinated seawater**

Seawater desalination, which converts ocean water to drinking water, is an option that could augment the tap water supply in the Orlando area. Desalination uses well established, tested, and effective water treatment technologies (e.g., reverse osmosis membranes). Desalination has been used extensively in other parts of the world and is beginning to be implemented more extensively in the United States, such as in the Tampa Bay area. Desalination provides a source of supply that is reliable and not impacted by droughts.

Desalination requires a large amount of energy and can be very expensive compared to current fresh ground water supplies. However, the cost of desalination relative to the development of other new water supply sources is becoming more favorable. Developments in technology have also reduced costs and energy requirements.

The desalinated water would need to be piped a long distance inland from Florida's east coast to the Orlando area, which would require additional energy. These high energy requirements result in a high carbon footprint relative to other water supply sources.

The environmental impacts of desalination can be a concern. When ocean water is drawn into the desalination plant, fish and other species can get trapped against the intake screens. Methods exist to minimize this impact and would be used.

The disposal of the salt and other compounds that are extracted from the seawater can also be a concern. However, the desal facility would be designed such that the salts removed from the seawater are safely mixed back into the ocean.

Finally, the desalination project would be developed in an aesthetically pleasing manner that will not impact local beach areas. The desal treatment plant would be located away from local beaches.

Next

**Increasing the use of recycled water**

About 10% of the water used in the Orlando area is highly purified recycled water. This recycled, or reclaimed, water is used to irrigate the lawns and landscaping of some single-family homes and golf courses in the Orlando area. Additional quantities of recycled water can be used to replace freshwater consumption. This water would be reclaimed from purified wastewater generated by water utility customers, and distributed throughout the city for suitable uses. After it is purified to meet applicable standards, recycled water can be used:

- For watering public landscape areas, parks, golf courses, and household yards.
- For some industrial processes, such as cooling in power plants.
- To replenish the local groundwater basin. This stored water could later be extracted, re-purified, and used for tap water.

Although recycled water offers significant potential as an alternative water supply source, there is typically too much of it available during periods of high rainfall and not enough of it available to meet demands during low rainfall periods.

Recycled water is produced constantly throughout the year, with no dramatic seasonal highs or lows. But irrigation, which currently is the most common use for reclaimed water in the Orlando area, fluctuates seasonally, with demand being higher from March to July. Thus, it is desirable to store unused recycled water during times of excess supply for use during times of peak demand.

- Recycled water could be stored underground in the local aquifer. The water could later be pumped and used as part of the Orlando area's water supply.
- If not used to replenish the local aquifer, recycled water would need to be stored in very large lakes located in the Orlando area. No recreation would be allowed on these lakes.

Screen 34

In addition, reclamation facilities are not necessarily located near the areas where the recycled water would be used, so the recycled water would have to be transported. Transmission lines and facilities can be expensive to construct, and disruptive (particularly in older or built-out areas).

Next

Screen 35

**Adding desalinated brackish groundwater**

Brackish (salty) ground water pumped from deep wells near the east coast of Florida can be purified to drinking water standards. This brackish water contains less salt than seawater so the treatment cost, including the energy required, is less than desalinating seawater. The cost to treat brackish water is greater than the cost to treat the existing fresh groundwater supply.

The desalinated water would need to be piped a long distance inland from Florida's east coast to the Orlando area and would require additional energy to transport. These high energy requirements result in a high carbon footprint relative to other water supply sources.

The disposal of the salt and other compounds that are extracted from the brackish water can be a concern. Possible disposal methods, such as deep wells and the ocean, are being evaluated to minimize negative impacts to water and ocean resources. The desalination project would not be located near beach areas.

Next

Screen 36

**Storing river water or recycled water underground when plentiful and withdrawing the water when needed**

Water storage could be expanded by importing water from the St. Johns River or other water bodies in years when waters are more plentiful, and storing it underground in the local groundwater basin, where it could be extracted and used locally in dry years.

Orlando could also increase the amount of recycled water it currently produces, and store it underground in the local groundwater basin. This would help replenish groundwater levels and could later be extracted, re-purified, and used for tap water and other uses. The water would be treated to meet ground water quality standards prior to injection.

Next

Screen 37

**Increasing the amount of water conservation**

A lot of individual water conservation measures have already been taken by residents and businesses in Orlando. However, there are still opportunities for additional conservation, especially for reducing outdoor water use by converting lawns at homes, athletic fields, and public parks to Florida-friendly landscaping, which requires less water than traditional turf grass. Increased water conservation actions could include:

- Rebates for indoor water-saving appliances
- Rebates for converting to low-water use landscaping (e.g., Florida-friendly landscaping)
- Mandatory low-water use landscaping for new homes
- Rebates for replacing sprinkler systems with low volume irrigation systems such as micro-spray, micro-jet, drip or bubbler irrigation systems
- Rebates for installing soil moisture sensors in irrigated lawns and landscaping.

Next

**Your Opinion on How We Should Meet Future Water Needs**

In the table below, you are presented with different options that water suppliers could undertake to improve the reliability of Orlando's future water supply.

Please rank your top 5 options for increasing future water supply in your local area according to your personal views. If you want to rank more, please feel free to do so.

Put a "1" for the option you would first like to see done to reduce future water shortages, a "2" next to your second most preferred option, and so on until you have ranked at least 5 options.

Type in the answer into each cell in the grid

| | |
|---|---|
| Expanding the use of recycled water for outdoor irrigation and industrial uses | |
| Using highly purified recycled water to replenish the local groundwater supply, allowing greater use of local groundwater | |
| Increasing available supplies by diverting surface water from the St. Johns River and storing it underground, allowing greater use of local groundwater | |
| Promoting more voluntary water conservation through additional education and incentives (e.g., rebates to convert to low water use landscaping and water efficient appliances) | |
| Increasing available supplies by diverting and storing surface water from the St. Johns River in reservoirs, and using these surface waters as part of the potable water supply | |
| Investing in desalination facilities to convert ocean waters into part of the local potable water supply | |
| Investing in desalination facilities to convert brackish groundwater near the east coast into part of the Orlando region's local potable water supply | |
| Increasing the price of water to residential, commercial, and industrial users so that they will use less | |
| Requiring low water use landscaping (e.g., Florida Friendly landscaping) in new homes and redevelopment projects | |

Screen 38

Next

Screen 39

Of these four options, which do you like the least?

Select one answer only

- ○ Investing in desalination facilities to convert ocean waters into part of the local potable water supply
- ○ Increasing the price of water to residential, commercial, and industrial users so that they will use less
- ○ Using highly purified recycled water to replenish the local groundwater supply, allowing greater use of local groundwater
- ○ Promoting more voluntary water conservation through additional education and incentives (e.g., rebates to convert to low water use landscaping and water efficient appliances)

Next

Screen 40

**Does it Matter How We Reduce Future Water Shortages?**

There are different ways that water suppliers can provide the same amount of water supply in the future. The next few questions ask you to choose among options that could be implemented to reduce the frequency of water shortages in the future. For each of the following questions, please indicate which option you prefer.

Next

Screen 41

Of the two underground water storage options below, which do you prefer?

Select one answer only

- ○ Increasing underground storage of local or imported surface water in wet years
- ○ Increasing underground storage of recycled water every year

Next

Screen 42

Of the two groundwater options below, which do you prefer?

Select one answer only

- ○ Increasing use of local groundwater sources by storing recycled or river water underground
- ○ Increasing use of non-local groundwater sources and pumping the water to Orlando

Next

## Screen 43

Of the two water import options below, which do you prefer?

Select one answer only

- ○ Importing and treating brackish groundwater from Florida's east coast
- ○ Importing water from the St. John's River and storing it in surface water reservoirs

Next

## Screen 44

Of the two water conservation options below, which do you prefer?

Select one answer only

- ○ Requiring low-water use landscaping in new homes
- ○ Promoting additional voluntary water conservation through education and incentives

Next

## Screen 45

Of the two water recycling options below, which do you prefer? Note that because new piping and storage is necessary for outdoor irrigation and industrial uses, expanding water recycling for outdoor irrigation and industrial uses costs three times as much as expanding water recycling to replenish groundwater supplies.

Select one answer only

- ○ Expanding water recycling to replenish local groundwater supplies
- ○ Expanding water recycling for outdoor irrigation and industrial uses

Next

How would you rate your perception of the quality of water supplied to you from these water sources and for these uses?

Select one answer from each row in the grid

| Water Source | Quality not good at all | Quality slightly good | Quality moderately good | Quality very good | Quality extremely good |
| --- | --- | --- | --- | --- | --- |
| Increasing fresh groundwater use (drinking water) | ○ | ○ | ○ | ○ | ○ |
| Diverting water from the St. Johns River to storage reservoirs (drinking water) | ○ | ○ | ○ | ○ | ○ |
| Storing river water underground when plentiful and withdrawing the water when needed (drinking water) | ○ | ○ | ○ | ○ | ○ |
| Adding desalinated seawater from the Atlantic Ocean (drinking water) | ○ | ○ | ○ | ○ | ○ |
| Adding desalinated brackish groundwater from wells near the east coast (drinking water) | ○ | ○ | ○ | ○ | ○ |
| Storing recycled water underground when plentiful and withdrawing the water when needed (drinking water) | ○ | ○ | ○ | ○ | ○ |
| Increasing the use of recycled water (irrigation and non-potable industrial uses) | ○ | ○ | ○ | ○ | ○ |
| | Quality not good at all | Quality slightly good | Quality moderately good | Quality very good | Quality extremely good |

Next

Screen 46

Screen 47

Thinking about this topic, do you have any comments you would like to share?

Any comments welcome!

Next

Screen 48

Thank you for completing this survey. We have successfully received your responses.

## C.4 San Francisco

# Value of Water Supply Reliability Survey Instrument: San Francisco Version

Screen shots from the Survey Instrument are provided below.

**Your Views on Issues in Northern California**

We are faced with many issues in Northern California, none of which can be solved easily or inexpensively. Below is a list of some of these issues. Some of them may be important to you personally, others may not be important to you personally. How important are the following issues to you?

Select one answer from each row in the grid

| **Issues in Northern California** | Not Important At All | Slightly Important | Moderately Important | Very Important | Extremely Important |
|---|---|---|---|---|---|
| Reducing taxes | ○ | ○ | ○ | ○ | ○ |
| Improving local libraries | ○ | ○ | ○ | ○ | ○ |
| Increasing water supplies | ○ | ○ | ○ | ○ | ○ |
| Reducing crime | ○ | ○ | ○ | ○ | ○ |
| Helping farmers increase their incomes | ○ | ○ | ○ | ○ | ○ |
| Improving education in public schools | ○ | ○ | ○ | ○ | ○ |

Next

Screen 1

This survey focuses on issues related to water in San Francisco and the greater Bay Area, and throughout the State of California.

Decisions are being made now that will affect the amount of water we will have available in the future. Water suppliers in the San Francisco region and across the state are interested in your views and opinions to help inform them as they make these decisions.

Next

Screen 2

How long have you lived in San Francisco?

Select one answer only

- ○ Less than 1 year
- ○ 1-2 years
- ○ 3-5 years
- ○ 6-10 years
- ○ More than 10 years

Next

Screen 3

How would you rate your local water supplier's performance in the following areas?

Select one answer from each row in the grid

| **Area** | Not good at all | Slightly good | Moderately good | Very good | Extremely good |
|---|---|---|---|---|---|
| Making sure you have enough water | ○ | ○ | ○ | ○ | ○ |
| Providing safe and healthy drinking water | ○ | ○ | ○ | ○ | ○ |
| Providing good tasting drinking water | ○ | ○ | ○ | ○ | ○ |
| Promoting water conservation | ○ | ○ | ○ | ○ | ○ |

Next

Screen 4

Screen 5

What type of residence do you live in?

Select one answer only

- ○ Home with its own yard
- ○ Townhouse or condominium with its own yard
- ○ Townhouse or condominium without its own yard
- ○ Apartment

Next

Screen 6[18]

Does your yard need regular watering to maintain either a lawn, garden area, or both?

Select one answer only

- ○ Yes
- ○ No

Next

Do you use or enjoy public parks, athletic fields, or other public green spaces that rely on outdoor watering?

Select one answer only

- ○ Yes
- ○ No

Next

Screen 7

Who pays your water bill?

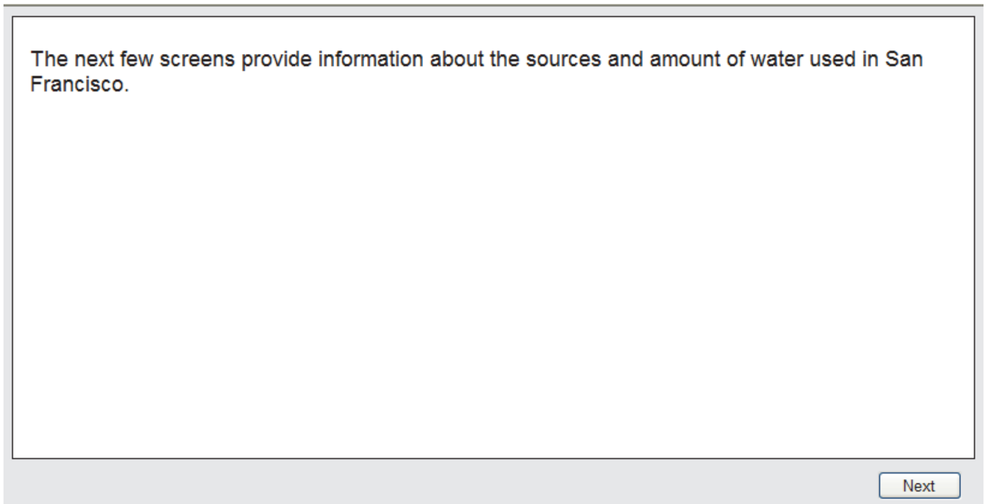
Select one answer only

- ○ My household pays its own water bill
- ○ My landlord pays the water bill
- ○ My water bill is part of my HOA fees
- ○ Other specify: ______
- ○ I don't know how my water bill is paid

Next

Screen 8

14. [18]. Screen 6 reflects the choice made in Screen 5.

Screen 9 
The next few screens provide information about the sources and amount of water used in San Francisco.
Next

**Current Water Use**

The San Francisco Public Utilities Commission (SFPUC) provides water to about 800,000 people within the City of San Francisco. SFPUC also sells water to 27 municipalities and water districts within the counties of San Mateo, Santa Clara, Alameda, and Tuolumne. Some of these communities and water districts are entirely reliant on SFPUC for their water supply. In total, the SFPUC service area includes about 2.4 million residents in the greater Bay Area.

SFPUC supplies about 265 million gallons of water per day (mgd) to residents and businesses within the Bay Area through the SFPUC Regional Water System (RWS). The SFPUC RWS provides 96% of SFPUC's total water supply (and 100% of its drinking water supply) and relies primarily on two sources of water supply, including:

- Diversions from the Tuolumne River through the Hetch Hetchy Water and Power Project (HHWP)
- Rainfall collected and stored in local Bay Area reservoirs

Water delivered to the Hetch Hetchy Reservoir through the HHWP Project represents the majority of the water supply available to San Francisco. On average, the HHWP Project provides 85% of the water delivered through the SFPUC RWS each year, while local rainwater collected and runoff stored in local reservoirs typically accounts for about 15% of total RWS supplies. During drought periods (i.e., during which very little runoff is stored in local reservoirs), water from the HHWP Project can account for more than 93% of total RWS water supply.

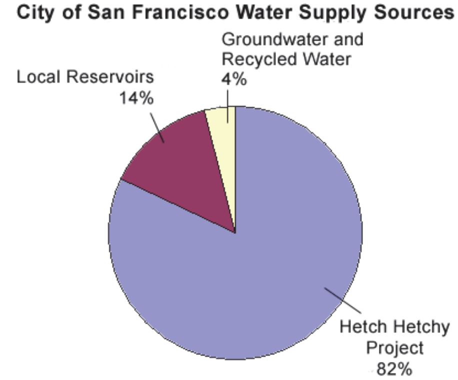
In addition to the SFPUC RWS, a small portion of San Francisco's total water demand (less than 5% of the total) is met through local groundwater supplies (which are used solely for outdoor watering). A very small portion is met through recycled water (which is used solely for equipment cleaning purposes).

**What is groundwater?**

**What is recycled water?**

The pie chart below shows the percentage of water supplied by SFPUC that comes from the different sources described above. Together, local reservoirs and the Hetch Hetchy project account for the water supplies delivered through RWS (which provides 96% of SFPUC's total water supply).

**City of San Francisco Water Supply Sources**




Next

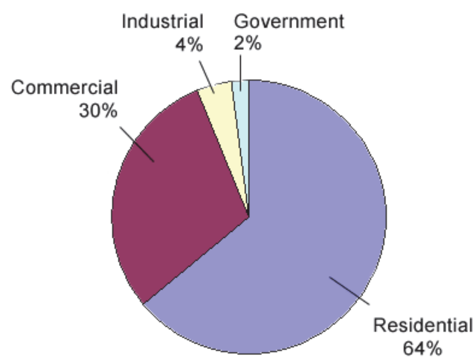
Screen 10

Screen 11

In San Francisco, average water use per person has been declining since the 1960s and 1970s. Several factors have contributed to this reduction, including changes in the mix of local water-using industrial and commercial businesses, and more efficient water use (i.e., water conservation) by San Francisco residents.

Currently, SFPUC provides close to 30 billion gallons of water each year to its customers within the City of San Francisco for a variety of different uses. The pie chart below shows how much water is used for residential, government, and commercial and industrial purposes. About two-thirds (62%) of water provided by SFPUC goes to residential customers.

**City of San Francisco Water Usage**




Next

Screen 12

The actual amount of water any one household uses depends on:

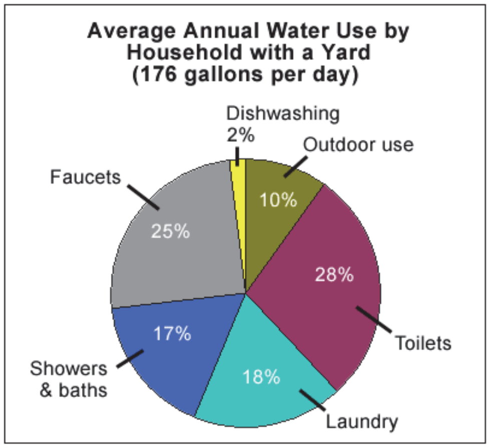
- The number of people who live in the house;
- What type of home it is, such as houses with their own yards, townhomes, condominiums, or apartments; and
- The amount and type of outdoor landscaping.

Due to the moderate climate and the high density housing in San Francisco, residential water use occurs mostly indoors. A typical San Francisco household with its own yard uses 176 gallons of water per day, on average (about 65,000 gallons per year). Households that do not have yards use about 158 gallons of water per day, on average (about 58,000 gallons per year).

Next

## Screen 13

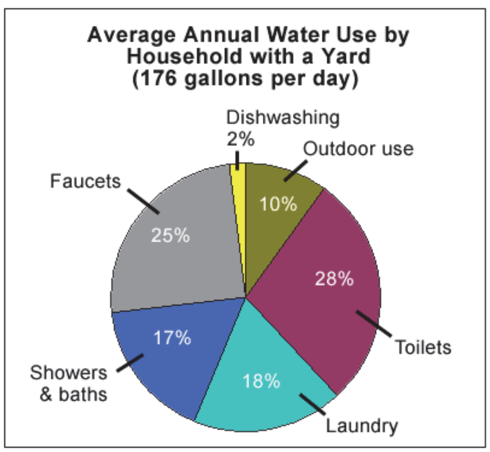
The pie chart below shows how an average household with its own yard uses water throughout the year.




Next

## Screen 14

In thinking about how your household uses water compared to the averages presented in the pie chart, does your household use more, less, or about the same amount of water for outdoor use?




Select one answer only

- ○ More
- ○ Less
- ○ About the same

Next

Screen 15

**CURRENT SUPPLIES MAY NOT MEET FUTURE DEMAND**

The goal of SFPUC is to match available water supplies with demand by taking into account snow pack, river flow, reservoir storage, climate, customer demand, and population estimates. This helps to ensure that there will be an adequate supply of clean water in the future.

Across the greater Bay Area, and most of California, periodic water shortages are anticipated over the coming decades. Even after accounting for savings associated with existing and planned water conservation activities, we expect water demands to increase across the Bay Area, and the State as a whole, over the next 20 years. There is also uncertainty over future rainfall, river levels, snow pack, and the amount of imported water that may be available to water users across the region and state in some future years. Combined, this means that water demands may periodically exceed available water supply over the next 20 years.

SFPUC and other water suppliers throughout the region and state are considering various options to ensure that enough clean water is available in the coming decades. For this reason, we are interested in your views on different options for avoiding future water shortages, and whether some of these options should be taken.

Regional water suppliers do not want to implement new options unless people are willing to pay for them. One way to find out about this is to give people like you information about possible new options, so that you can make up your own mind about them.

Some people think the options they are asked about are not needed; others think they are. We want to get the opinions of all kinds of people.

Next

Screen 16

**Methods to Address Current Water Shortages**

In San Francisco, there are some water use rules that are always in place. For example, flooding or runoff of excess irrigation water from lawns into the street or gutters is prohibited, and there is a requirement that all homes and buildings install low-water use toilets, showerheads, and sinks when they replace old fixtures.

In addition, in advance of an anticipated minor water supply shortage, SFPUC will implement a number of measures to encourage water conservation by its customers. For example, SFPUC will alert water customers to the current status of water supply conditions, and remind them of existing water use prohibitions. SFPUC also will remind customers of currently available incentives and programs that will help them reduce their water use (such as rebates for installing water efficient fixtures and appliances). If a modest shortage is expected, SFPUC may also initiate new rebate programs ahead of their planned implementation dates, in order to promote the associated water savings in the near-term. In most cities, the goal of these types of actions is to reduce overall water use in the city by up to 10%.

Next

When there is not enough water to meet demand, additional mandatory water use restrictions become necessary, and they can have significant effects on residents, local businesses, and public parks.

To address water shortages, SFPUC currently has two stages of mandatory water use restrictions that can be applied in addition to any existing water use restrictions or voluntary conservation measures. The stage selected depends on the severity of water shortages.

**Stage 1 Restrictions.** The objective of Stage 1 restrictions is to achieve a system-wide reduction in water use of 11 to 20%. In addition to the permanent water use restrictions and voluntary measures described on the previous screen, under Stage 1 water use restrictions:

- All customers receive a monthly allotment of water based on past indoor and outdoor water use.
- Customers using more than their allotted amount pay "excess use" charges, and may be subject to having devices installed on their water service line that will restrict the flow of water they can receive (or may have their water service shut off).
- Additional water use restrictions may be applied and enforced. For example:
    - The use of water to clean sidewalks, patios, or other hard surfaces is prohibited.
    - Water suitable for drinking cannot be used to clean, fill or maintain levels in decorative fountains.
    - Use of additional water is not allowed for new landscaping or expansion of existing facilities unless low water use landscaping designs and irrigation systems are employed.

Screen 17

- Water service connections for new construction may be granted only if water saving fixtures or devices are incorporated into the plumbing system.

**Stage 2 Restrictions** The objective of Stage 2 restrictions is to achieve a reduction in water use of more than 20%. Stage 2 water use restrictions would be placed on top of the existing permanent water use restrictions and Stage 1 restrictions described above. Under Stage 2 water use restrictions, additional water use prohibitions and restrictions would be implemented, and customers would be subject to an increased level of rationing. Most outdoor watering would not be allowed.

Next

Screen 18

Stage 1 restrictions can lead to brown lawns and temporary damage to landscaping for households and public parks.

- Lawns and landscaping can recover if these restrictions are needed for only one year.
- If water shortages require Stage 1 restrictions multiple years in a row, this can lead to dead lawns and landscaping for households and public parks.
- Dead lawns and landscaping would require replacement or conversion to low-water use landscaping (e.g., xeriscape).
- Lawns and public parks irrigated with recycled water would not be impacted because they are not subject to Stage 1 restrictions.

Stage 2 restrictions can lead to dead lawns and landscaping for households and public parks after only one year. Lawns and public parks irrigated with recycled water would not be impacted because they are not subject to Stage 2 restrictions.

Next

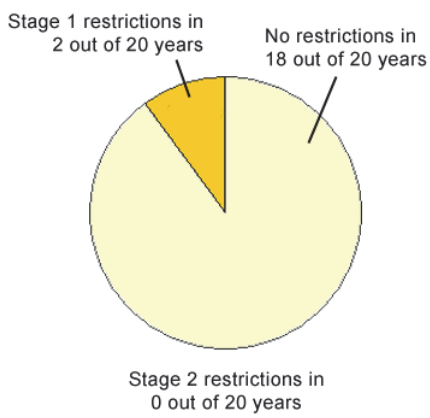
SFPUC Stage 1 and Stage 2 water use restrictions are in addition to any voluntary water use restrictions implemented in advance of an anticipated shortage. Stage 1 and Stage 2 water use restrictions are put in place if water shortages become severe or prolonged. Restrictions typically remain in place over a period of several months, and can be lifted by SFPUC as the severity of a water shortage is reduced. In multi-year drought periods, Stage 1 or Stage 2 restrictions may be required for 2 or 3 years in a row.

In San Francisco, water use restrictions have tended to occur with the following frequencies over the past 20 years:

- No restrictions (excluding voluntary water conservation programs) have been in place in 18 of the past 20 years
- Stage 1 restrictions have been needed in 2 of the past 20 years
- Stage 2 restrictions have not been needed in the last 20 years.

The pie chart below shows how often the different water use restrictions have been in place in San Francisco over the last 20 years.

Screen 19




Some other communities in the Bay Area have had more frequent and severe water shortages over the past two decades than San Francisco itself. This is because they rely in whole or in part on other sources of water supply.

Next

Screen 20

**Water Suppliers Need to Identify a Water Supply Strategy**

Developing new water supplies can help reduce the frequency and severity of future water shortages. SFPUC and other regional water suppliers are developing long-term water supply reliability strategies to evaluate how much, if any, additional water supplies should be developed to meet future needs.

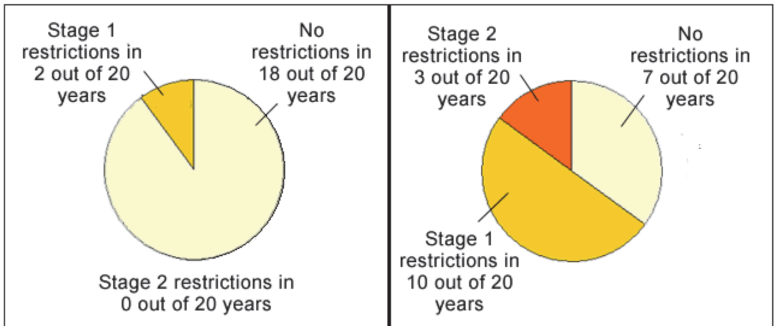
While additional water supplies are not mandatory, without new supplies, water use restrictions in parts of the greater Bay Area, and across the State, may become more severe and frequent in the future.

Next

The two pie charts below compare the frequency of water use restrictions in the past with restrictions that may occur in the future if no new water supplies are developed.

- The pie chart on the left shows that, in the City of San Francisco, Stage 1 restrictions have been needed in 2 out of the past 20 years. Stage 2 restrictions have not yet been required. This is the same chart you saw on a previous screen.
- The pie chart on the right is a projection of what the future could be like for the greater Bay Area region, and other parts of the state, if no new water supplies are developed. It shows that Stage 1 restrictions are likely to be more frequent in the future than in the past, and that Stage 2 restrictions are likely to be needed in 3 years out of 20 if no actions are taken to develop new water supplies.

Screen 21




**Trend over the past 20 years, for City of San Francisco**

**Predicted Bay Area Region water use restrictions over next 20 years if nothing more is done**

Next

Screen 22

**Your Opinion on How Much Should be Done to Increase Future Water Supplies**

The more water supplies that are developed to meet future needs, the more you and other state residents will have to pay for water in the future. These costs would be passed on to you through your monthly water bill.

Water suppliers do not want to develop new water supplies unless people like you are willing to pay for them. For this reason, they are trying to balance the amount of water supplies in the future against the costs you would face.

On the next three screens, you will have an opportunity to provide your views on reducing the severity of future water use restrictions based on six alternative water supply plans. In later sections, you can provide your opinions on different options for how additional future water supplies, if any, should be developed.

Next

In the table below, you are presented with predicted levels of future water use restrictions given different future water supply plans. The table also shows the increased costs to you under each plan.

The first row uses pie charts to show the frequency of different stages of water use restrictions in the next 20 years given different levels of available water supply.

Under the No Additional Actions column, aside from the permanent water use restrictions that are always in place, no additional restrictions will be needed in 7 of the next 20 years. Stage 1 water use restrictions will be in place 10 of the next 20 years, and Stage 2 restrictions will be in place in 3 of the next 20 years.

The exact timing and length of future restrictions is unknown, but it is likely that restrictions could be in place for multiple years in a row (e.g., two seasons of Stage 1 restrictions may be followed by a year of Stage 2 restrictions). This is because drought periods often last 2 or 3 years in a row, and may be followed by one or more years in a row that are wetter. Over the past 20 years, Stage 1 restrictions have occurred in 2 years, and there have been no Stage 2 restrictions.

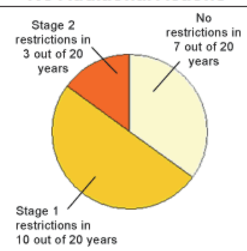
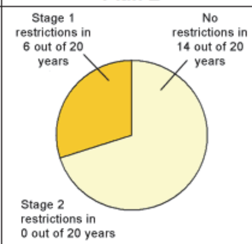
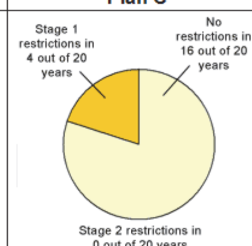
If you would like to be reminded of the permanent water use restrictions, and Stage 1 and Stage 2 restrictions, please click the button on the right. More Info

Water Supply Plans B and C both increase water supplies and have different levels of restrictions over the next 20 years. The second row of the table shows the increase in your water cost under each plan. Under the No Additional Actions column, your monthly water costs will increase by $1, which means that you will pay an additional $12 per year.

If you choose to spend money for a plan that increases water supplies, that money will not be available for you to buy other things.

Screen 23

Please review the table and check the box under the plan you most prefer.

| | No Additional Actions | Plan B | Plan C |
|---|---|---|---|
| Available water supply such that water use restrictions in the next 20 years could be: |  |  |  |
| Increase in your water cost | $1 per month, which would be $12 per year | $13 per month, which would be $150 per year | $15 per month, which would be $180 per year |
| **Which plan do you prefer?** | ○ | ○ | ○ |

Next

## Screen 24[19]

Please provide a brief comment to help us understand why you chose $13 per month, which would be $150 per year, as your most preferred plan.

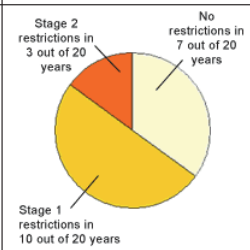
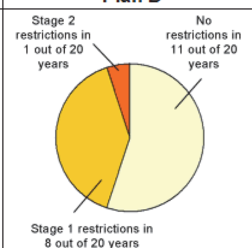
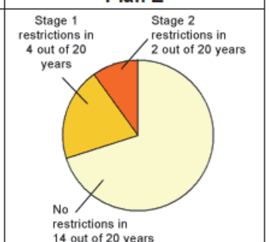
Type in the answer

Next

## Screen 25

This table presents some additional expected future water use restrictions in the next 20 years based on alternative water supply plans, at different costs to you.

Please review the table and check the box under the plan you most prefer.

| | **No Additional Actions** | **Plan D** | **Plan E** |
|---|---|---|---|
| Available water supply such that water use restrictions in the next 20 years could be: |   |   |   |
| Increase in your water cost | $1 per month, which would be $12 per year | $13 per month, which would be $160 per year | $11 per month, which would be $130 per year |
| **Which plan do you prefer?** | ○ | ○ | ○ |

Next

15. [19]. Screen 24 reflects the choice made in Screen 23.

## Screen 26[20]

Please provide a brief comment to help us understand why you chose $13 per month, which would be $160 per year, as your most preferred plan.

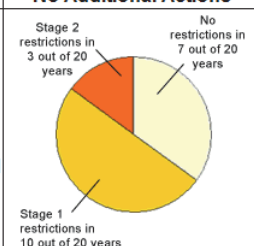
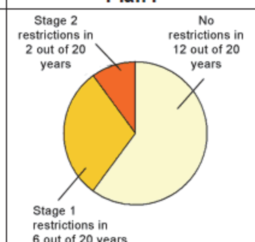
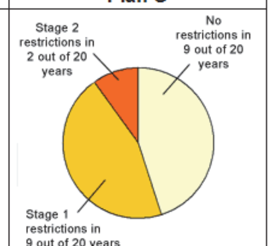
Type in the answer

Next

## Screen 27

This table presents some additional expected future water use restrictions in the next 20 years based on alternative water supply plans, at different costs to you.

Please review the table and check the box under the plan you most prefer.

| | **No Additional Actions** | **Plan F** | **Plan G** |
|---|---|---|---|
| Available water supply such that water use restrictions in the next 20 years could be: |   |   |   |
| Increase in your water cost | $1 per month, which would be $12 per year | $8 per month, which would be $95 per year | $7 per month, which would be $80 per year |
| **Which plan do you prefer?** | ○ | ○ | ○ |

Next

16. [20]. Screen 26 reflects the choice made in Screen 25.

Screen 28[21]

Please provide a brief comment to help us understand why you chose $8 per month, which would be $95 per year, as your most preferred plan.

Type in the answer

Next

**Your Opinion on How We Should Increase Future Water Supplies**

There are a number of different options that can be considered to increase the amount of water available in the future to reduce water use shortages and increase the reliability of supplies. We want your opinions about which possible future water supply options you like, and which ones you do not like.

While no actions are perfect, there are opportunities to improve the reliability of future water supplies and reduce the frequency and severity of future water use restrictions.

The options we want you to consider include:

- Increasing water storage capacity (such as by expanding reservoirs)
- Increasing groundwater use
- Importing additional water to the region
- Transferring water from agricultural uses
- Increasing the amount of water conservation
- Increasing the use of recycled water
- Adding desalinated water

Screen 29

The next few screens provide more details on each of these options.

Next

17. [21]. Screen 28 reflects the choice made in Screen 27.

Screen 30

**Adding desalinated water**

Some California water suppliers are exploring the possibility of developing regional desalination facilities to convert ocean water to drinking water.

Desalination facilities use well established, tested, and effective water treatment technologies (e.g., reverse osmosis membranes). Desalination has been used extensively in other parts of the world and is beginning to be implemented more extensively in the United States. Desalination provides a local source of supply that is reliable and not impacted by weather or climate.

Desalination requires a large amount of energy and can be relatively expensive. However, the cost of desalination relative to the development of other new water supply sources is becoming more favorable. Developments in technology have also decreased costs.

The environmental impacts of desalination can be a concern, if proper precautions are not taken. When ocean water is drawn into the desalination plant, fish and other species can get trapped against the intake screens. To avoid this problem, California water suppliers are focusing on the use of new technologies that minimize these potential environmental effects. For example, new path-breaking beach sand water intake systems that will not harm fish have been developed and tested in California (because they eliminate the need for an ocean intake pipe).

The disposal of the salt and other compounds that are extracted from the seawater can be a concern. However, potential regional desalination facilities will be designed such that the salts removed from the seawater are safely mixed back into the ocean.

In California, water agencies would also develop desalination projects in an aesthetically pleasing manner that will not impact local beach areas. Desalination treatment plants can be located inland, away from local beaches.

Next

Screen 31

**Increasing water storage capacity**

Water storage could be expanded by increasing the capacity of reservoirs throughout the State. Additional storage would allow water suppliers to store more water in years when water is plentiful.

Increasing the size of existing reservoirs or building new reservoirs could potentially create additional recreation opportunities. However, it might also reduce recreational opportunities on some rivers. It may also have some negative effects on ecosystems, including:

- Loss of river and wildlife habitat
- Decreased flows in some rivers at some times of the year, which could impact some fish and other types of wildlife that rely on adequate stream flows

Next

Screen 32

**Increasing the amount of water conservation**

A lot of individual water conservation measures have already been taken by residents and businesses in San Francisco, the greater Bay Area, and other parts of the state. However, there are still opportunities for additional conservation measures, especially for reducing outdoor water use. Increased water conservation actions could include:

- Rebates for water-saving appliances
- Rebates for converting to low-water use landscaping (e.g., Xeriscape)
- Mandatory low-water landscaping for new homes

In some cases, the amount of water saved from individual water conservation measures is small when compared to typical water supply development alternatives. Conservation programs also can be relatively expensive, given the amount of water they actually save.

Next

Screen 33

**Transferring water from agricultural uses**

Improvements in how agriculture uses water could be made, which would reduce the amount of water that is needed by farmers. This saved water could be transferred to urban areas in the state (including the Bay Area) for residential and business uses. Water could be saved by having water supply utilities:

- Pay for the use of improved agricultural irrigation systems that can reduce the amount of water lost to evaporation.
- Pay the extra cost for farmers to use new plant breeds that can provide the same harvest with less water.

Next

Screen 34

**Increasing groundwater use**

Groundwater is water that collects or flows beneath the Earth's surface, filling the porous spaces in soil, sediment, and rocks. Groundwater originates from rain and from melting snow and ice that soaks into the ground, and is the source of water for aquifers, springs, and wells. High-quality groundwater can be used for drinking water supplies.

In most of California, expanding local groundwater use would only be possible if additional water is used to replenish the local groundwater system. The amount of additional groundwater that could be used in most areas of the State is therefore very limited. Without additional water being supplied to the groundwater system, groundwater supplies would ultimately be depleted.

Groundwater supplies in the Bay Area could be replenished faster if the amount of green area in the region is increased or if special materials are used for sidewalks, roads and other pavement areas. Green areas and special pavement materials allow water to infiltrate into the ground and provide other social and environmental benefits. However, the use of green space or special pavement material can be expensive.

Next

Screen 35

**Importing additional water into the region**

Additional water supplies for the greater Bay Area could be acquired by importing water from river basins outside of the San Francisco region. Importing additional water from other river basins may have some negative consequences. Removing water from distant rivers and lakes could:

- Harm ecosystems and limit recreational opportunities in the basins from which the water is taken
- Limit the amount of water available to people living near the rivers from which the water is exported
- Increase energy costs associated with transferring the water to the Bay Area

In addition, imported water could become less available in the future, due to court rulings, regulations, droughts, or earthquakes that might disrupt long import water supply canals and pipelines.

Next

**Increasing the use of recycled water**

In much of the Bay Area and California, a small percentage of current water supply is made up of highly purified recycled water. Many water suppliers would like to increase the amount of recycled water they produce, and make the recycled water available for suitable uses. After it is purified to meet applicable standards, recycled water can be used:

- For watering public landscape areas, parks, and golf courses. It might also be available for watering some household yards.
- For some industrial processes, such as cooling in power plants.
- For other limited non-drinking water uses such as toilet flushing.
- To replenish groundwater basins in some parts of the state. This stored water is later extracted, re-purified, and used for various purposes, including tap water in some parts of the state.

The use of recycled water is not impacted by external factors such as drought or climate change. Recycled water is therefore considered a very reliable source of water supply.

However, because new piping is necessary for outdoor irrigation and industrial uses, expanding water recycling for outdoor irrigation and industrial uses can be expensive due to high up-front construction costs and high energy use associated with additional pumping and distribution of the recycled water.

Screen 36

Next

**Your Opinion on How We Should Meet Future Water Needs**

In the table below, you are presented with different options that could be undertaken to improve future water supply reliability in the greater Bay Area and elsewhere in the State.

Put a "1" for the option you would first like to see done to reduce future water shortages, a "2" next to your second most preferred option, and so on until you have ranked at least 5 options.

Type in the answer into each cell in the grid

| | |
|---|---|
| Increasing available supplies of water by expanding or adding new storage reservoirs so more water can be stored from wet years | |
| Expanding the use of recycled water for outdoor irrigation and industrial uses | |
| Using highly purified recycled water to replenish groundwater supplies in parts of the state, thereby enabling greater use of local well water in those areas | |
| Promoting voluntary water conservation through education and incentives (e.g., rebates for homes that switch to low water using appliances or landscaping) | |
| Finding new surface water supplies outside the Bay Area region (i.e., importing water from other parts of the State) | |
| Increasing available supplies of water by transferring more water from agricultural uses in the state to urban areas such as the Bay Area | |
| Investing in regional desalination facilities, to convert ocean, bay, or brackish waters into part of the local drinking water supply in some regions | |
| Increasing the price of water to residential, commercial, and industrial users so they will use less | |
| Requiring low water landscaping (e.g., Xeriscape) in new homes and redevelopment projects | |

Screen 37

Next

Screen 38

Of these four options, which do you like the <u>least</u>?

Select one answer only

- ○ Increasing available supplies of water by transferring more water from agricultural uses in the state to urban areas such as the Bay Area
- ○ Increasing the price of water to residential, commercial, and industrial users so they will use less
- ○ Expanding the use of recycled water for outdoor irrigation and industrial uses
- ○ Promoting voluntary water conservation through education and incentives (e.g., rebates for homes that switch to low water using appliances or landscaping)

Next

Screen 39

**Does it Matter How We Reduce Future Water Shortages?**

There are different ways that water suppliers can provide adequate amounts of water supply in the future. The next few questions ask you to choose among options that could be implemented to reduce the frequency of water shortages in the future. For each of the following questions, please indicate which option you prefer.

Next

Screen 40

Of the two water storage options below, which do you prefer?

Select one answer only

- ○ Increasing water storage capacity by expanding or building new reservoirs in the Bay Area
- ○ Increasing water storage capacity by expanding existing reservoirs or building new reservoirs in other areas of the state (and importing the water to the Bay Area)

Next

Screen 41

Of the two water transfer and import options below, which do you prefer?

Select one answer only

- ○ Increasing water transfers from agriculture
- ○ Increasing water imports from outside of the Bay Area region

Next

Screen 42

Of the two water conservation options below, which do you prefer?

Select one answer only

- ○ Requiring low-water landscaping in new homes and existing homes that remodel more than 1,000 square feet
- ○ Promoting additional voluntary water conservation beyond what is already required through education and incentives

Next

Screen 43

Of the two water recycling options below, which do you prefer? Note that because new piping is necessary for outdoor irrigation and industrial uses, expanding water recycling for outdoor irrigation and industrial uses costs three times as much as expanding water recycling to replenish groundwater supplies.

Select one answer only

- ○ Expanding water recycling to replenish groundwater supplies in parts of the state
- ○ Expanding water recycling for outdoor irrigation and industrial uses

Next

Screen 44

Many of the options discussed above apply to the broader Bay Area or to the Northern California region. In thinking about water supply planning for the City of San Francisco, we want to know if you think SFPUC should consider the approaches described below. Some of these options may be under consideration by SFPUC, and some may not. Please indicate whether you agree or disagree with each of the following statements:

Select one answer from each row in the grid

| | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|
| SFPUC should actively expand the amount of water conservation in the City | ○ | ○ | ○ | ○ | ○ |
| SFPUC should consider expanding the amount of recycled water used in the City | ○ | ○ | ○ | ○ | ○ |
| SFPUC should seriously consider desalination to provide more water to the City | ○ | ○ | ○ | ○ | ○ |
| SFPUC should raise rates for households and businesses that use more than their fair share of water | ○ | ○ | ○ | ○ | ○ |

Next

Screen 45

Thinking about this topic, do you have any comments you would like to share?

Any comments welcome!

Next

Screen 46

Thank you for completing this survey. We have successfully received your responses.

*Appendix D*

# Data Analysis of a Willingness to Pay Stated Choice Survey of Water Supply Reliability in the Austin Water Service Area

## D.1 Introduction

Knowledge Networks (KN) administered the water supply reliability survey to 406 panelists within the Austin Water service area from August 11, 2010 to August 18, 2010. KN administered the survey to 101 people on the KnowledgeNetwork™ Internet Panel; the remaining sample was supplemented using another Internet panel (e-Rewards). To ensure that all respondents received their water from the City of Austin, Stratus Consulting provided KN with a list of zip codes that were completely contained within the Austin Water service area.

Respondents were presented with three sets of choice questions near the end of the survey in order to evaluate their preferences for a range of possible programs to reduce (to varying degrees) different levels of water use restrictions over the next 20 years. Each choice set allowed respondents to choose the program called “No Additional Actions,” which we refer to in this report as the “status quo.” The experimental design for this study comprised 24 different programs with varying levels of use restrictions. For each choice set, KN randomly selected two of these programs. Once a program was selected in any of the choice questions for a given participant, it was not selected again in future choice questions (i.e., no replacement of programs). This allowed us to get three choice set data observations for each respondent.

The results presented in the following sections rely on 406 observations from Austin, Texas. Weights were generated by KN to adjust for sample design, non-coverage, and non-response biases. These weights were used in the analysis in order to generalize results to residents of specific Austin zip codes who participated in the study.

The following sections present the results of this analysis. Section 2 presents how select respondent characteristics affected the likelihood of a respondent choosing an alternative to the status quo. This includes a summary of education, age, gender, income, ownership status of living quarters, work status, opinion on increasing water supplies, ownership status of yard, and payment of water bill. Section 3 presents the distribution of choices by version alternative. Sections 4, 5, and 6 provide more detailed empirical analysis of the data, including willingness to pay (WTP) estimates and respondent preferences for specific water supply options.

## D.2 Characteristics Predicting Choice Behavior

This section presents how select respondent characteristics affected the likelihood of choosing an alternative to the status quo. Since each respondent was asked three choice questions, there are multiple ways to define a binary choice variable that indicates a respondent's choice for the status quo or an alternative. The most stringent definition – the one used for this analysis – requires a respondent to have chosen an alternative to the status quo in all three choice questions for this choice variable to take on a value of 1, and 0 otherwise. The following cross tabs demonstrate how various respondent characteristics affected the outcome of this choice variable.

### D.2.1 Education

Table 1 demonstrates a positive relationship between education level and the likelihood of choosing alternatives to the status quo in all three choice questions.

**Table 1. Education (*n* = 405[a])**

| Choice | Less than high school (%) | High school (%) | Some college (%) | Bachelor (%) |
|---|---|---|---|---|
| Status quo | 100.0 | 100 | 68.9 | 45.8 |
| Alternative | 0.0 | 0 | 31.1 | 54.2 |

a. 405 out of the 406 respondents completed the choice questions; thus only 405 observations support Table 1.

### D.2.2 Age

Table 2 suggests that older individuals (45+) are slightly more likely to choose alternatives to the status quo than their younger counterparts.

**Table 2. Age (*n* = 405)**

| Choice | 18–29 (%) | 30–44 (%) | 45–59 (%) | 60+ (%) |
|---|---|---|---|---|
| Status quo | 62.5 | 65.0 | 56.1 | 57.9 |
| Alternative | 37.5 | 35.0 | 44.0 | 42.1 |

### D.3.3 Gender

Table 3 demonstrates that there is no difference in the likelihood of choosing alternatives to the status quo across gender.

**Table 3. Gender (*n* = 405)**

| Choice | Male (%) | Female (%) |
|---|---|---|
| Status quo | 60.8 | 60.5 |
| Alternative | 39.2 | 39.5 |

### D.2.4 Income

Table 4 shows an increased likelihood of choosing alternatives to the status quo in all three choice questions for individuals with household incomes of greater than $75,000. At lower income levels, this relationship is not as clear.

**Table 4. Income (*n* = 391)**

| Choice | < $20,000 (%) | $20,000–$29,999 (%) | $30,000–$49,999 (%) | $50,000-$74,999 (%) | $75,000–$99,999 (%) | > $100,000 (%) |
|---|---|---|---|---|---|---|
| Status quo | 67.8 | 76.8 | 60.4 | 74.3 | 44.1 | 46.5 |
| Alternative | 32.2 | 23.2 | 39.6 | 25.8 | 55.9 | 53.5 |

### D.2.5 Ownership status of living quarters

Table 5 reveals a clear difference between respondents who own or rent their living quarters with payment compared to those who occupy their living quarters without payment of cash rent. Respondents who do not pay for their living quarters are more likely to choose alternatives to the status quo.

**Table 5. Ownership status of living quarters (*n* = 405)**

| Choice | Owned or being bought by you or someone in your household (%) | Rented for cash (%) | Occupied without payment of cash rent (%) |
|---|---|---|---|
| Status quo | 59.8 | 63.5 | 49.3 |
| Alternative | 40.2 | 36.6 | 50.7 |

### D.2.6 Work status

Work status appears to affect a respondent's likelihood of choosing alternatives to the status quo in all three choice questions, as shown in Table 6. Respondents who are not working due to a disability or who are not working but looking for work have the greatest likelihood of choosing alternatives to the status quo. Those not working due to a temporary layoff universally chose the status quo.

**Table 6. Work status (*n* = 405)**

| Choice | Working – as a paid employee (%) | Working – self-employed (%) | Not working – on temporary layoff from job (%) | Not working – looking for work (%) | Not working – retired (%) | Not working – disabled (%) | Not working – other (%) |
|---|---|---|---|---|---|---|---|
| Status quo | 57.8 | 60.6 | 100.0 | 52.0 | 59.3 | 31.2 | 83.2 |
| Alternative | 42.2 | 39.4 | 0 | 48.0 | 40.6 | 68.8 | 16.8 |

### D.2.7 Opinion on increasing water supplies

Question 2 of the survey asked respondents how important "increasing water supplies" is as an issue in Texas. Table 7 shows respondents who answered "very" or "extremely important" to Question 2 had a greater likelihood of choosing alternatives to the status quo in all three choice questions than those who consider the issue less important.

**Table 7. Opinion on increasing water supplies (*n* = 405)**

| Choice | Increasing water supplies of low importance (%) | Increasing water supplies of high importance (%) |
|---|---|---|
| Status quo | 66.1 | 56.9 |
| Alternative | 33.9 | 43.1 |

### D.2.8 Ownership status of yard

Table 8 shows that respondents who own a yard have a much higher likelihood of choosing alternatives to the status quo across choice questions.

**Table 8. Ownership status of yard (*n* = 405)**

| Choice | Do not own yard (%) | Own yard (%) |
|---|---|---|
| Status quo | 77.8 | 56.2 |
| Alternative | 22.3 | 43.8 |

### D.2.9 Payment of water bill

Table 9 shows a higher proportion of respondents who pay their own water bill choosing alternatives to the status quo in all three choice questions compared to those who do not pay their own bill.

**Table 9. Payment of water bill (*n* = 405)**

| Choice | Does not pay own bill (%) | Pays own bill (%) |
|---|---|---|
| Status quo | 74.5 | 58.8 |
| Alternative | 25.5 | 39.4 |

### D.2.10 Time living in Austin

Table 10 demonstrates no clear relationship between the amount of time an individual has been living in Austin and the likelihood of choosing an alternative to the status quo. However, individuals living in Austin for 6 or more years are less likely to choose an alternative relative to individuals living in the city for 3 to 5 years.

**Table 10. Time living in Austin (*n* = 405)**

| Choice | Less than 1 year (%) | 1–2 years (%) | 3–5 years (%) | 6–10 years (%) | More than 10 years (%) |
|---|---|---|---|---|---|
| Status quo | 100 | 85.2 | 43.4 | 59.6 | 61.7 |
| Alternative | 0 | 14.8 | 56.6 | 40.5 | 38.3 |

It is difficult to draw conclusions about the relationship between the amount of time a respondent has been living in Austin and the likelihood of choosing an alternative to the status quo because the sub-populations for some categories are very small. Only about 6.2% of respondents have been living in Austin for fewer than 10 years. As shown in Table 10, the majority of this small sample did not choose an alternative. The majority of respondents sampled (70.5%) have been living in Austin for more than 10 years. These respondents chose an alternative to the status quo at a much higher rate.

## D.3 Distribution of Choices by Version Alternative

Table 11 and Figures 1 and 2 summarize the distribution of choices across the status quo, alternatives, and refusals. In Table 11, the column titled "Percentage chosen" displays the percentage of respondents who chose each version out of the respondents who were presented that version. For example, of the respondents who were presented Version 1, 46.7% chose Version 1 over the status quo and the other version presented. There are 1,218 observations underlying Table 11, as each of the

406 respondents were asked three choice questions. Although this analysis does not address the variation of alternative versions presented to respondents,

**Table 11. Distribution of choices by version alternative (*n* = 1,218)**

| Version | Summers with Level 1 restrictions | Summers with Level 2 restrictions | Summers with Level 3 restrictions | Cost per year | Cost per month | Percentage chosen |
|---|---|---|---|---|---|---|
| Refused | | | | | | 0.8 |
| Status quo | 8 | 8 | 4 | 12 | 1 | 45.4 |
| 1 | 11 | 8 | 1 | 160 | 13 | 46.7 |
| 2 | 12 | 6 | 2 | 95 | 8 | 22.1 |
| 3 | 13 | 5 | 2 | 210 | 18 | 11.2 |
| 4 | 15 | 5 | 0 | 300 | 25 | 10.0 |
| 5 | 10 | 8 | 2 | 60 | 5 | 41.6 |
| 6 | 11 | 6 | 3 | 130 | 11 | 7.0 |
| 7 | 13 | 7 | 0 | 240 | 20 | 17.9 |
| 8 | 15 | 4 | 1 | 290 | 24 | 9.7 |
| 9 | 12 | 5 | 3 | 90 | 8 | 24.2 |
| 10 | 12 | 8 | 0 | 110 | 9 | 33.2 |
| 11 | 9 | 8 | 3 | 65 | 5 | 26.7 |
| 12 | 14 | 6 | 0 | 150 | 13 | 35.6 |
| 13 | 13 | 6 | 1 | 220 | 18 | 29.6 |
| 14 | 11 | 7 | 2 | 150 | 13 | 20.7 |
| 15 | 8 | 9 | 3 | 20 | 2 | 35.2 |
| 16 | 10 | 7 | 3 | 55 | 5 | 18.8 |
| 17 | 14 | 4 | 2 | 130 | 11 | 26.4% |
| 18 | 14 | 5 | 1 | 140 | 12 | 24.3 |
| 19 | 13 | 4 | 3 | 200 | 17 | 19.3 |
| 20 | 12 | 7 | 1 | 100 | 8 | 39.3 |
| 21 | 11 | 9 | 0 | 170 | 14 | 25.1 |
| 22 | 16 | 4 | 0 | 180 | 15 | 37.2 |
| 23 | 9 | 9 | 2 | 80 | 7 | 35.6 |
| 24 | 10 | 9 | 1 | 65 | 5 | 53.8 |

Table 11 and Figures 1 and 2 provide feedback about respondent responses to each alternative version. About half of the responses were refusals or choices for the status quo (46.2%). The remaining responses were allocated across alternatives to the status quo, with more responses allocated to alternatives with lower costs.

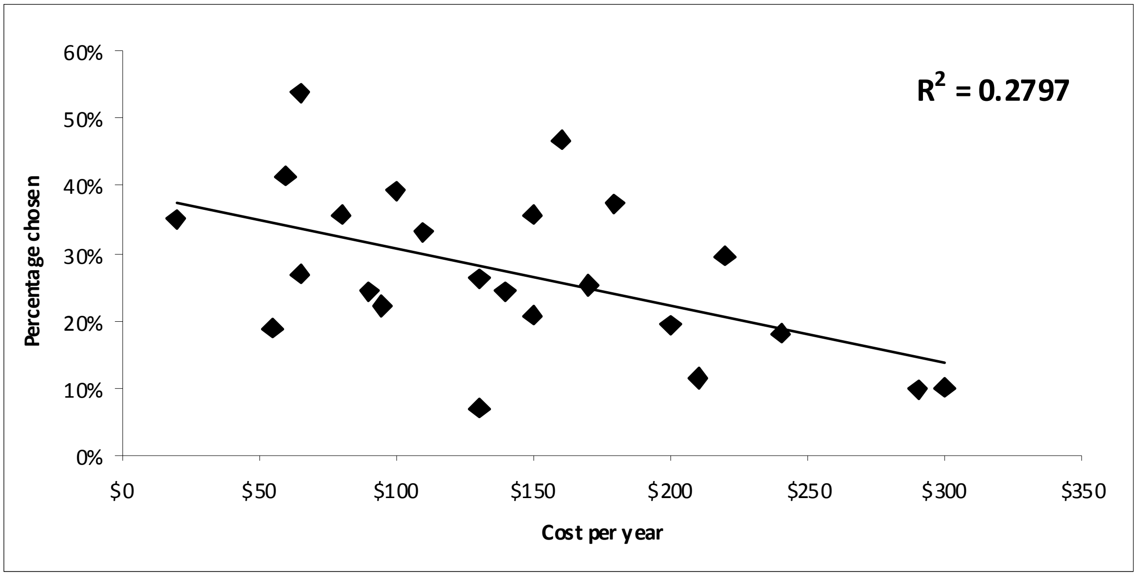



**Figure 1. Distribution of choices by program cost.**

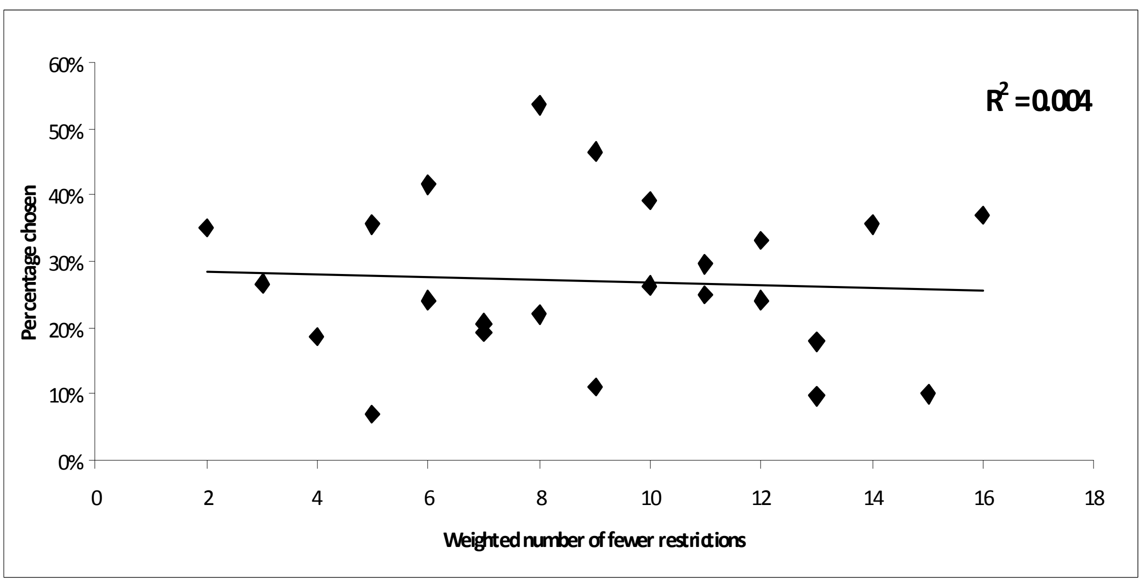



**Figure 2. Distribution of choices by number of (weighted) fewer restriction years.**

Figures 1 and 2 show the distribution of choices by the cost of each alternative (Figure 1) as well as the distribution of choices by the number of fewer restriction years[22] (Figure 2). Based on these figures, program cost seems to play a larger role in the decision to choose an alternative than the number of fewer restriction years that the alternative offers. The figures illustrate that the correlation between program cost and the percentage of time an alternative was chosen (when it was presented to respondents) was 0.28. This is compared to a correlation of 0.004 between the percentage of time an alternative was chosen and the number of fewer restriction years the alternative would provide.

## D.4 Supply Option Preferences

Question 16 asked respondents to rank different options that water suppliers could undertake to improve future water supply reliability. There were 10 choices presented on the survey, including:

1. Increasing available supplies of water by importing more water from outside the Lower Colorado River basin
2. Increasing available supplies of water by transferring more water from agricultural uses
3. Increasing the use of non-local groundwater sources
4. Increasing the price of water to residential, commercial, and industrial users so that they will use less
5. Requiring low-water-use landscaping in new homes (e.g., Xeriscape)
6. Increasing available supplies of water by expanding storage reservoirs
7. Increasing the use of local groundwater sources
8. Expanding water recycling for outdoor irrigation and industrial uses
9. Promoting voluntary water conservation through education and incentives (e.g., rebates)
10. Expanding water recycling to replenish groundwater reservoir supplies.

Respondents were asked to rank their top five most-preferred options. Figure 3 shows the percentage of respondents who selected each option as one of their top three most-preferred choices for dealing with future water shortages.

Four responses stand out as the preferred choices: expanding water recycling for outdoor irrigation and industrial uses; promoting voluntary water conservation through education and incentives; using recycled water to replenish groundwater supplies; and requiring low-water-use landscaping for new homes. Expanding reservoirs was also a relatively popular option.

[22]. The number of fewer Level 2 restriction years was assigned a weight of 3 to represent the significance respondents placed on reducing Level 2 restrictions compared to Level 1 restrictions, which are much less severe.

Question 16A of the survey asked respondents to choose their least preferred option of the remaining unranked choices. Figure 4 reveals that about one-third of respondents chose increasing the price of water to residential, commercial, and industrial users as their least preferred option. Almost one-quarter of respondents chose increasing supplies of water by importing water from outside the Lower Colorado River basin as the option they prefer the least.

In addition to the supply option preferences reflected above, we also asked specific questions about preferences for different versions of similar program options. For example, we asked respondents to indicate which of the two water storage options they preferred and which of the two water reuse options they preferred. Responses are summarized in Tables 12–16.

## D.5 Conditional Logit Model for Estimating WTP

Economists use a variety of models to analyze the type of data collected in the choice questions used in this survey. A well-accepted and straightforward model often applied is the conditional logit model. This model is used to estimate the probabilistic effect of a choice attribute or personal characteristic on the outcome of a given choice.

Since a respondent's choice is contingent on observed and random respondent characteristics, our model includes several variables to account for the variation in observed characteristics of a choice. We include the cost of the alternative associated with a given choice. We also define two attributes as the number of fewer restriction years relative to the status quo for each restriction level. Finally, we include personal characteristics, including education, age, income, a dummy variable indicating whether the respondent believes increasing water supplies is of high or low importance, the amount of time living in Austin, a dummy variable indicating yard ownership status, and a dummy variable indicating whether a respondent pays his or her own water bill. The personal characteristics are interacted with a dummy variable indicating whether the choice decision concerns an alternative to the status quo. This provides variability to the data and allows the model to estimate the impact of personal characteristics on choosing an alternative to the status quo.

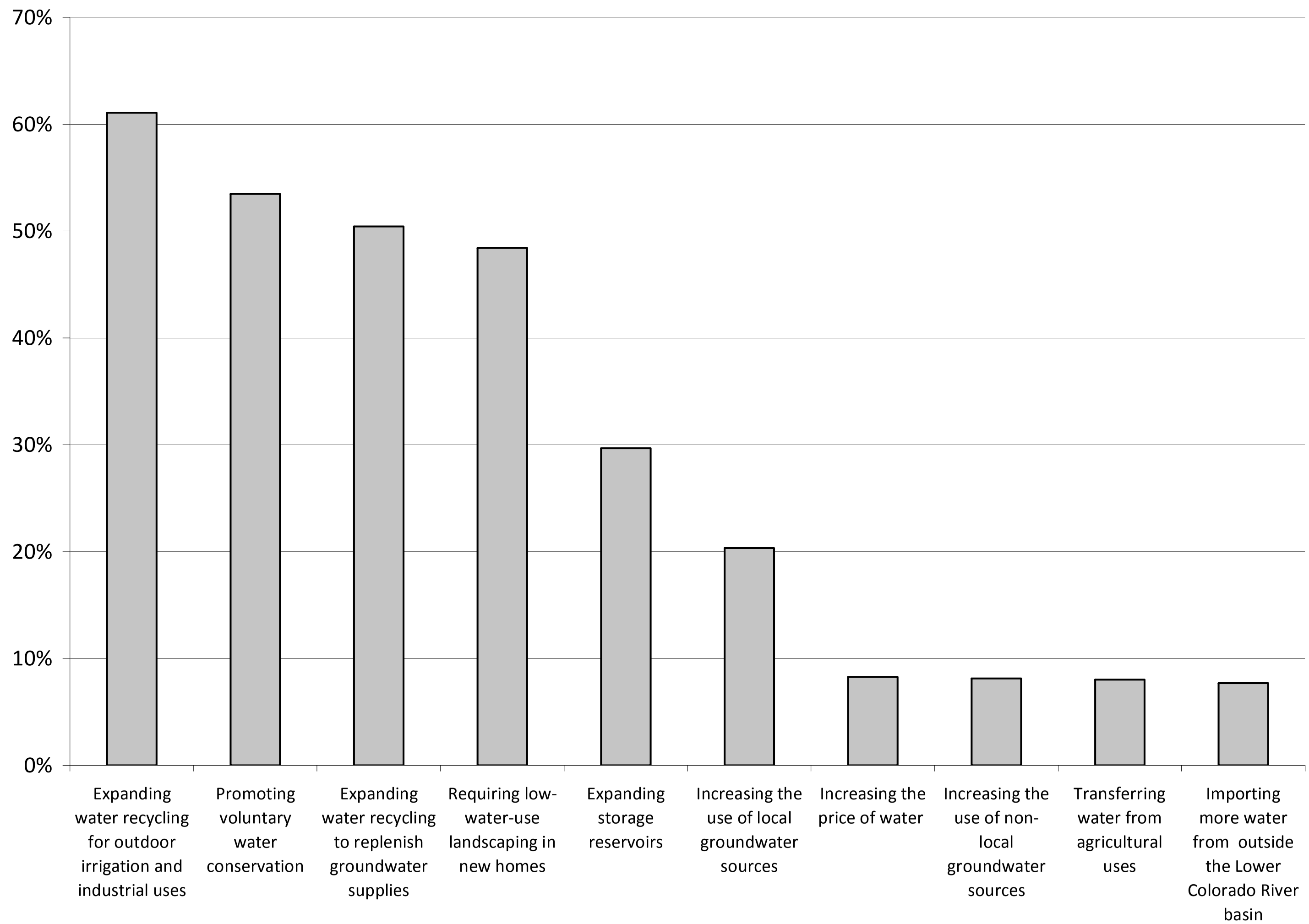



**Figure 3. Percentage of respondents who selected a given option as one of their top three choices for dealing with future water shortages**.

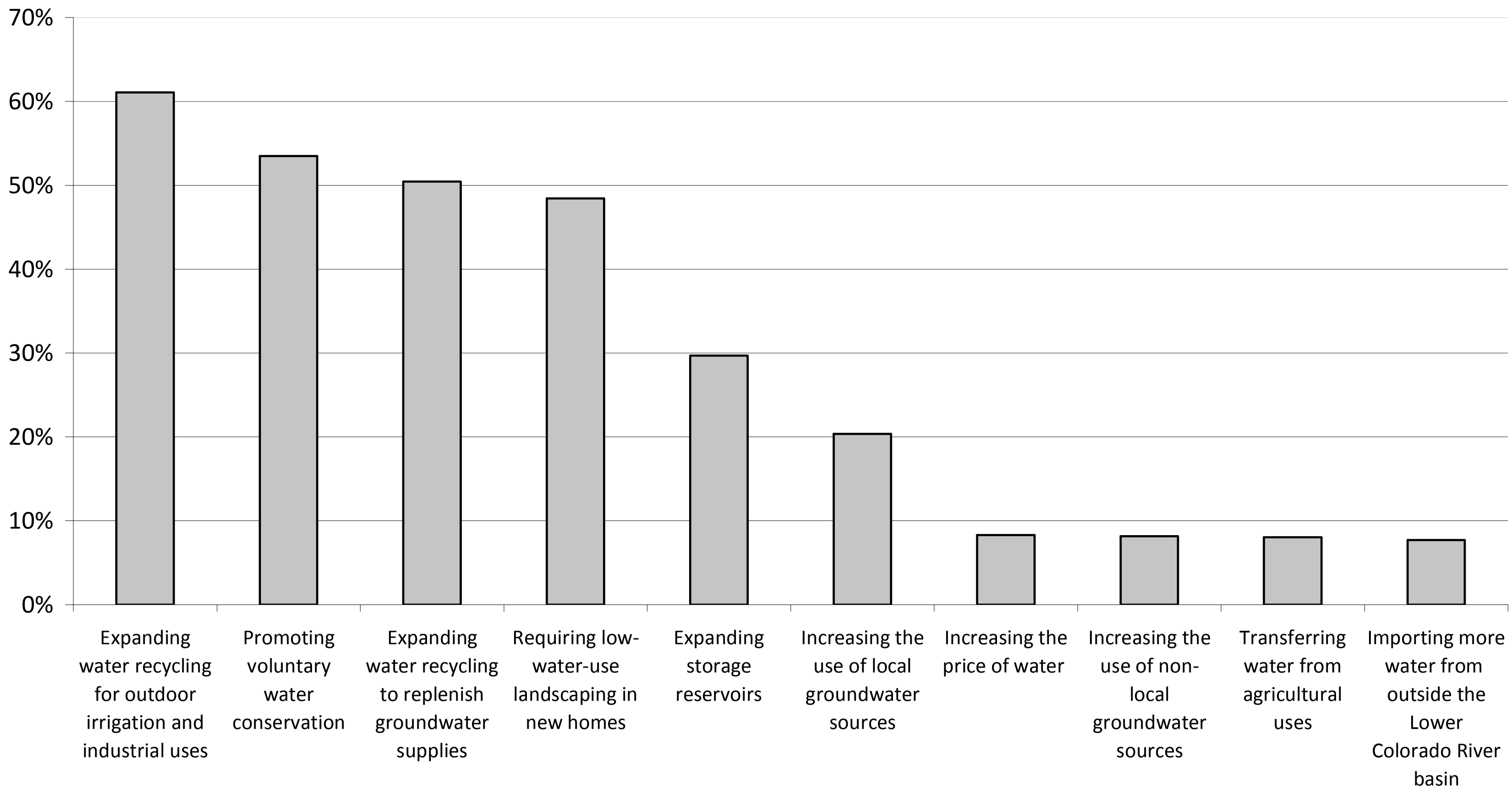



**Figure 4. Percentage of respondents who selected a given option as their least preferred option for dealing with future water shortages**

**Table 12. Q17: Of the two water storage options below, which do you prefer?**

| | |
|---|---|
| Refused | 2.2% |
| Increasing surface reservoir storage | 33.6% |
| Increasing underground water storage | 64.3% |

**Table 13. Q17a: Of the two water storage options below, which do you prefer?**

| | |
|---|---|
| Refused | 0.2% |
| Increasing use of local groundwater sources | 77.7% |
| Increasing use of non-local groundwater sources | 22.2% |

**Table 14. Q18: Of the two water transfer and import options below, which do you prefer?**

| | |
|---|---|
| Refused | 0.2% |
| Increasing water imports from outside the Lower Colorado River basin | 48.5% |
| Increasing water transfers from agriculture | 51.2% |

**Table 15. Q19: Of the two water conservation options below, which do you prefer?**

| | |
|---|---|
| Refused | 0.0% |
| Requiring low-water-use landscaping in new homes | 48.7% |
| Promoting voluntary water conservation through education and incentives | 51.3% |

**Table 16. Q20: Of the two water recycling options below, which do you prefer?[a]**

| | |
|---|---|
| Refused | 0.0% |
| Expanding water recycling for outdoor irrigation and industrial uses | 37.2% |
| Expanding water recycling to replenish reservoir supplies | 62.9% |

a. Note that because new piping is necessary for outdoor irrigation and industrial uses, expanding water recycling for outdoor irrigation and industrial uses costs three times as much as expanding water recycling to replenish reservoir supplies.

Table 17 displays the results from the conditional logit model. The model uses 3,513 observations, an expansion of the 406 observations by nine choices (three choice questions and three choices per question), less 141 observations due to questions that were left unanswered by respondents.

**Table 17. Conditional logit model for selecting an option as an alternative to the status quo (*n* = 3,513; log likelihood = -1,159.557)**

| Choice | Coefficient | Robust standard error | *z* | *P* > \|*z*\| | [95% confidence | interval] |
|---|---|---|---|---|---|---|
| Cost per year | -0.009 | 0.002 | -4.60 | 0.000 | -0.012 | -0.005 |
| Reduction in Level 2 restrictions[a] | 0.00061 | 0.059 | 0.01 | 0.992 | -0.114 | 0.116 |
| Reduction in Level 3 restrictions | 0.297 | 0.092 | 3.21 | 0.001 | 0.115 | 0.478 |
| Chose alternative education | 0.275 | 0.131 | 2.10 | 0.036 | 0.018 | 0.532 |
| Chose alternative × age | -0.078 | 0.108 | -0.72 | 0.471 | -0.291 | 0.135 |
| Chose alternative × income | 0.255 | 0.078 | 3.26 | 0.001 | 0.101 | 0.409 |
| Chose alternative × increasing water supplies important | 0.792 | 0.207 | 3.83 | 0.000 | 0.387 | 1.197 |
| Chose alternative × time living in Austin | -0.496 | 0.112 | -4.43 | 0.000 | -0.716 | -0.277 |
| Chose alternative × own yard | 0.333 | 0.335 | 0.99 | 0.320 | -0.323 | 0.990 |
| Chose alternative × pay water bill | -0.425 | 0.399 | -1.06 | 0.288 | -1.208 | 0.358 |

a. WTP to reduce Level 1 restrictions was not evaluated because it is assumed that Level 1 restrictions will remain permanently in place in the future.

As expected, cost has a negative impact on the likelihood of choosing a given option (i.e., as cost increases, the likelihood of choosing an alternative decreases). Time spent living in Austin is also found to have a negative impact on the likelihood of choosing a given option, while income and higher education have a positive impact. Finally, respondents who feel that increasing water supplies is an important issue in their community are more likely to choose an alternative option. The other variables are not statistically significant from zero in the model estimated.

Note that the empirical conclusion above assumes a constant (i.e., linear) WTP for reductions in restriction years. Additional statistical analyses have been conducted to explore potential non-linear effects of changes in restriction years on WTP (i.e., to explore whether the anticipated reduction in marginal WTP is observed as the number of avoided restrictions declines).

Our more complex empirical analyses were aimed to better examine how the WTP estimates may be influenced by the total number of years of restrictions avoided (rather than assuming each year is valued equally, regardless of how many years in total have use restrictions eliminated). The results of our empirical evaluation (shown below) revealed no statistically significant difference between the linear results reported above and the non-linear variations we estimated.

## D.6 WTP Measures

Using the parameter estimates from the conditional logit model in Section 5, we calculated WTP measures for reducing Level 2 and Level 3 restrictions. Table 18 presents the estimated mean WTP for a one-summer reduction in each restriction separately. As shown, the WTP estimate for reducing Level 2 restrictions is not statistically significant from zero. This means that respondents are not willing to pay to reduce Level 2 restrictions. The mean WTP for reducing Level 3 restrictions by 1 summer out of the next 20 is statistically significant from zero. These results imply a positive WTP by respondents for increasing water reliability to avoid Level 3 restrictions.

**Table 18. WTP estimates (*n* = 3,513)**

| Choice | Coefficient | Robust standard error | $z$ | $P > \|z\|$ | [95% confidence interval] | |
|---|---|---|---|---|---|---|
| WTP to reduce Level 2 restrictions by 1 summer out of the next 20 | 0.07 | 6.70 | 0.01 | 0.99 | -13.07 | 13.21 |
| WTP to reduce Level 3 restrictions by 1 summer out of the next 20 | 33.94 | 7.15 | 4.74 | 0.00 | 19.92 | 47.96 |
| WTP to avoid all restrictions | 135.76 | 28.62 | 4.74 | 0.00 | 79.67 | 191.85 |

a. WTP to avoid all restrictions assumes that WTP to reduce Level 1 restrictions by 1 summer out of the next 20 is $0.

To interpret these results in the context of understanding the mean household WTP for specific water supply enhancement programs, one needs to add the mean values based on the number and type of restrictions the program is expected to eliminate. For example, in the survey, the next 20 years were portrayed as yielding an anticipated eight summers with Level 1 restrictions, eight summers with Level 2 restrictions, and four summers with Level 3 restrictions. Suppose an ambitious supply enhancement program was expected to eliminate imposition of all of the projected Level 2 and Level 3 use restrictions. The mean annual WTP results above suggest that the total household WTP for this program would be ($0 × 8) + ($33.94 × 4) = $135.76 per year. This conclusion assumes a constant WTP for reductions in restriction years.

To gauge the strength of this assumption, we estimated several models with non-linear specifications. Using the best-fit non-linear model, the mean WTP for a program that eliminates the imposition of all projected Level 2 and Level 3 use restrictions = $123.63. This estimate is not statistically different from the estimate using the linear model ($135.76). More generally, we find that the linear model underestimates WTP for smaller changes in summers with restrictions relative to the non-linear models and overestimates WTP for larger changes in summers with restrictions. However, in the range of reductions presented in the survey scenarios, the linear model provides a reliable average approximation of WTP for these scenarios.

*Appendix E*

# Data Analysis of a Willingness to Pay Stated Choice Survey of Water Supply Reliability in the Long Beach Water Department Service Area

## E.1 Introduction

Knowledge Networks (KN) administered the water supply reliability survey to 426 panelists within the Long Beach Water Department (LBWD) service area from October 25, 2010 through November 8, 2010. KN administered the survey to 23 people on the KnowledgeNetwork™ Internet Panel; the remaining sample was supplemented using another Internet panel (e-Rewards). To ensure that all respondents received their water from the City of Long Beach, Stratus Consulting provided KN with a list of zip codes that were completely contained within the LBWD service area.

Respondents were presented with three sets of choice questions near the end of the survey in order to evaluate their preferences for a range of possible programs to reduce (to varying degrees) different levels of water use restrictions over the next 20 years. Each choice set allowed respondents to choose the program called "No Additional Actions," which we refer to in this report as the "status quo." The experimental design for this study comprised 24 different programs with varying levels of use restrictions. For each choice set, KN randomly selected two of these programs. Once a program was selected in any of the choice questions for a given participant, it was not selected again in future choice questions (i.e., no replacement of programs). This allowed us to get three choice set data observations for each respondent.

The results presented in the following sections rely on 426 observations from Long Beach, California. Weights were generated by KN to adjust for sample design, non-coverage, and nonresponse biases. These weights were used in the analysis in order to generalize results to residents of specific zip codes who participated in the study.

The following sections present the results of this analysis. Section 2 presents how select respondent characteristics affected the likelihood of a respondent choosing an alternative to the status quo. This includes a summary of education, age, gender, income, ownership status of living quarters, work status, opinion on increasing water supplies, ownership status of yard, payment of water bill, and length of time living in Long Beach. Section 3 presents the distribution of choices by version alternative. Sections 4, 5, and 6 provide more detailed empirical analysis of the data, including willingness to pay (WTP) estimates and respondent preferences for specific water supply options.

## E.2 Characteristics Predicting Choice Behavior

This section presents how select respondent characteristics affected the likelihood of choosing an alternative to the status quo. Since each respondent was asked three choice questions, there are multiple ways to define a binary choice variable that would indicate a respondent's choice for the status quo or an alternative. The most stringent definition – the one used for this analysis – requires a respondent to have chosen an alternative to the status quo in all three choice questions for this choice variable to take on a value of 1, and 0 otherwise. The following tables demonstrate how various respondent characteristics affected the outcome of this choice variable.

### E.2.1 Education

Table 1 demonstrates a positive relationship between education level and the likelihood of choosing alternatives to the status quo in all three choice questions.

**Table 1. Education (*n* = 424[a])**

| Choice | Less than high school (%) | High school (%) | Some college (%) | Bachelors (%) |
|---|---|---|---|---|
| Status quo | 88.6 | 75.4 | 74.0 | 69.9 |
| Alternative | 11.4 | 24.6 | 26.0 | 30.1 |

a. 424 out of the 426 respondents completed the choice questions; thus only 424 observations support Table 1.

### E.2.2 Age

Table 2 suggests that individuals over the age of 30 are less likely to choose alternatives to the status quo compared to their younger counterparts.

**Table 2. Age (*n* = 424)**

| Choice | 18–29 (%) | 30–44 (%) | 45–59 (%) | 60 + (%) |
|---|---|---|---|---|
| Status quo | 67.2 | 77.2 | 75.0 | 78.2 |
| Alternative | 32.9 | 22.8 | 25.0 | 21.8 |

### E.2.3 Gender

Table 3 demonstrates that males are slightly more likely to choose an alternative to the status quo than females.

**Table 3. Gender (*n* = 424)**

| Choice | Male (%) | Female (%) |
|---|---|---|
| Status quo | 72.3 | 75.8 |
| Alternative | 27.7 | 24.2 |

### E.2.4 Income

Table 4 shows an increased likelihood of choosing alternatives to the status quo in all three choice questions for individuals with household incomes of between $20,000 to $29,999; $50,000 to $74,999; and over $100,000. Overall, there seems to be no clear trend in the way that income affects an individual's decision to choose an alternative to the status quo. However, households that make less than $20,000 per year are much less likely to choose an alternative compared to households in higher income categories.

**Table 4. Income (*n* = 424)**

| Choice | < $20,000 (%) | $20,000–$29,999 (%) | $30,000–$49,999 (%) | $50,000-$74,999 (%) | $75,000–$99,999 (%) | > $100,000 (%) |
|---|---|---|---|---|---|---|
| Status quo | 89.0% | 69.7% | 77.7% | 66.6% | 74.6% | 72.1% |
| Alternative | 11.0% | 30.3% | 22.3% | 33.4% | 25.4% | 27.9% |

### E.2.5 Ownership status of living quarters

Table 5 reveals that respondents who rent their living quarters with payment are more likely to choose an alternative to the status quo compared to those who own their living quarters. Respondents who do not pay for their living quarters are less likely to choose alternatives to the status quo compared to both cash payment renters and owners.

**Table 5. Ownership status of living quarters (*n* = 424)**

| Choice | Owned or being bought by you or someone in your household (%) | Rented for cash (%) | Occupied without payment of cash rent (%) |
|---|---|---|---|
| Status quo | 75.6 | 71.2 | 79.6 |
| Alternative | 24.4 | 28.8 | 20.4 |

### E.2.6 Work status

Work status appears to affect a respondent's likelihood of choosing alternatives to the status quo in all three choice questions, as shown in Table 6. Respondents who are not working due to a disability or who are not working but looking for work are less likely to choose an alternative to the status quo. Respondents that are self-employed, not working due to a temporary layoff from their job, or not working due to other reasons, are the most likely to choose an alternative to the status quo.

**Table 6. Work status (*n* = 424)**

| Choice | Working – as a paid employee (%) | Working – self-employed (%) | Not working – on temporary layoff from job (%) | Not working – looking for work (%) | Not working – retired (%) | Not working – disabled (%) | Not working – other (%) |
|---|---|---|---|---|---|---|---|
| Status quo | 74.3 | 69.2 | 68.8 | 79.0 | 73.6 | 84.5 | 65.2 |
| Alternative | 25.7 | 30.8 | 31.2 | 21.0 | 26.4 | 15.5 | 34.8 |

### E.2.7 Opinion on increasing water supplies

Question 2 of the survey asked respondents how important "increasing water supplies" is as an issue in Southern California. As shown in Table 7, respondents who answered "very" or "extremely" important to Question 2 have a greater likelihood of choosing alternatives to the status quo in all three choice questions.

**Table 7. Opinion on increasing water supplies (*n* = 424)**

| Choice | Increasing water supplies low importance (%) | Increasing water supplies high importance (%) |
|---|---|---|
| Status quo | 76.6 | 73.0 |
| Alternative | 23.5 | 27.0 |

### E.2.8 Ownership status of yard

Table 8 shows that respondents who do not own a yard have a higher likelihood of choosing alternatives to the status quo across all three choice questions.

**Table 8. Ownership status of yard (*n* = 424)**

| Choice | Do not own yard (%) | Own yard (%) |
|---|---|---|
| Status quo | 69.1 | 77.1 |
| Alternative | 30.9 | 22.9 |

### E.2.9 Payment of water bill

Table 9 shows that a lower proportion of respondents who pay their own water bill chose alternatives to the status quo, compared to those who do not pay their own bill.

**Table 9. Payment of water bill (*n* = 424)**

| Choice | Does not pay own bill (%) | Pays own bill (%) |
|---|---|---|
| Status quo | 70.2 | 76.3 |
| Alternative | 29.8 | 23.7 |

### E.2.10 Time living in Long Beach

Table 10 shows that individuals that have been living in Long Beach for three or more years are much more likely to choose an alternative compared to individuals that have lived in the city for less time.

It is difficult to draw conclusions about the relationship between the amount of time a respondent has been living in Long Beach and their likelihood of choosing an alternative to the status quo because the sub-populations for some categories are very small. Only about 2.8% of respondents have been living in Long Beach for less than 1 year, and about 6.5% have been living in Long Beach for 1 to 2 years. The majority of respondents sampled (70.1%) have been living in Long Beach for more than 10 years. These respondents chose an alternative to the status quo at a much higher rate.

**Table 10. Time living in Long Beach (*n* = 424)**

| Choice | Less than 1 year (%) | 1–2 years (%) | 3–5 years (%) | 6–10 years (%) | More than 10 years (%) |
|---|---|---|---|---|---|
| Status quo | 91.9 | 91.9 | 72.0 | 62.4 | 74.0 |
| Alternative | 8.1 | 8.1 | 28.0 | 37.6 | 26.0 |

## E.3 Distribution of Choices by Version Alternative

Table 11 and Figures 1 and 2 summarize the distribution of choices across the status quo, alternatives, and refusals. In Table 11, the column titled “Percentage chosen” displays the percentage of respondents who chose each version out of the respondents who were presented that version. For example, of the respondents who were presented Version 1, 24% chose Version 1 over the status quo and the other version presented. There are 1,278 observations underlying Table 11 as each of the 426 respondents were asked three choice questions. Although this analysis does not address the variation of alternative versions presented to respondents, Table 11 and Figures 1 and 2 provide feedback about respondent responses to each alternative version. More than half of the responses were refusals or choices for the status quo (62.5%). The remaining responses were allocated across alternatives to the status quo.

**Table 11. Distribution of choices by version alternative (*n* = 1,278)**

| Version | Summers with Level 1 restrictions | Summers with Level 2 restrictions | Summers with Level 3 restrictions | Cost per year | Cost per month | Percentage chosen |
|---|---|---|---|---|---|---|
| Refused | | | | | | 0.8 |
| Status quo | 7 | 10 | 3 | 12 | 1 | 61.7 |
| 1 | 11 | 8 | 1 | 160 | 13 | 24.2 |
| 2 | 12 | 6 | 2 | 95 | 8 | 16.9 |
| 3 | 13 | 5 | 2 | 210 | 18 | 4.8 |
| 4 | 15 | 5 | 0 | 300 | 25 | 12.4 |
| 5 | 10 | 8 | 2 | 60 | 5 | 18.8 |
| 6 | 11 | 6 | 3 | 130 | 11 | 10.9 |
| 7 | 13 | 7 | 0 | 240 | 20 | 12.7 |
| 8 | 15 | 4 | 1 | 290 | 24 | 8.7 |
| 9 | 12 | 5 | 3 | 90 | 8 | 22.0 |
| 10 | 12 | 8 | 0 | 110 | 9 | 37.0 |
| 11 | 9 | 8 | 3 | 65 | 5 | 16.0 |
| 12 | 14 | 6 | 0 | 150 | 13 | 23.0 |
| 13 | 13 | 6 | 1 | 220 | 18 | 12.1 |
| 14 | 11 | 7 | 2 | 150 | 13 | 10.2 |
| 15 | 8 | 9 | 3 | 20 | 2 | 33.2 |
| 16 | 10 | 7 | 3 | 55 | 5 | 28.1 |
| 17 | 14 | 4 | 2 | 130 | 11 | 13.5 |
| 18 | 14 | 5 | 1 | 140 | 12 | 16.3 |
| 19 | 13 | 4 | 3 | 200 | 17 | 13.3 |

**Table 11. Distribution of choices by version alternative (*n* = 1,278) (cont.)**

| Version | Summers with Level 1 restrictions | Summers with Level 2 restrictions | Summers with Level 3 restrictions | Cost per year | Cost per month | Percentage chosen |
|---|---|---|---|---|---|---|
| 20 | 12 | 7 | 1 | 100 | 8 | 16.5 |
| 21 | 11 | 9 | 0 | 170 | 14 | 17.2 |
| 22 | 16 | 4 | 0 | 180 | 15 | 23.4 |
| 23 | 9 | 9 | 2 | 80 | 7 | 25.5 |
| 24 | 10 | 9 | 1 | 65 | 5 | 34.3 |

Figures 1 and 2 show the distribution of choices by the cost of each alternative (Figure 1) as well as the distribution of choices by the number of fewer restriction years[23] (Figure 2). Based on these figures, program cost seems to play a larger role in the decision to choose an alternative than the number of fewer restriction years that the alternative offers. The figures illustrate that the correlation between program cost and the percentage of time an alternative was chosen (when it was presented to respondents) was 0.3998. This is compared to a correlation of 0.0394 between the percentage of time an alternative was chosen and the number of fewer restriction years the alternative would provide.

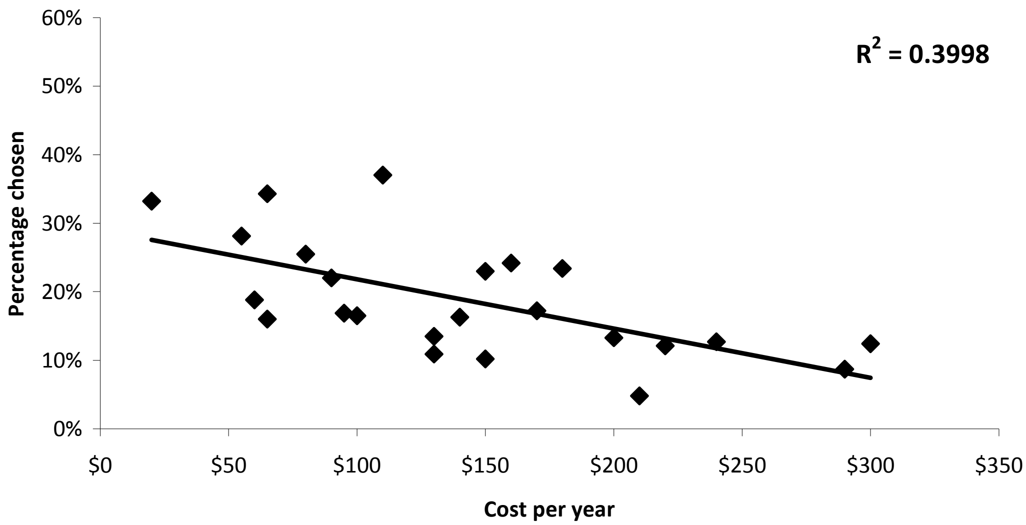



**Figure 1. Distribution of choices by program cost.**

18. [23]. The number of fewer Level 2 restriction years was assigned a weight of 3 to represent the significance respondents placed on reducing Level 2 restrictions compared to Level 1 restrictions, which are much less severe.

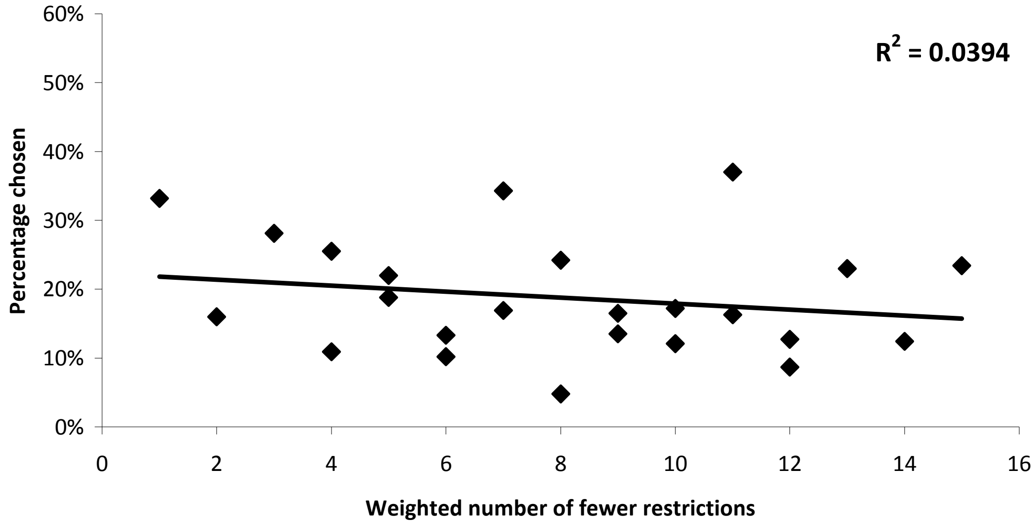



**Figure 2. Distribution of choices by number of (weighted) fewer restriction years.**

## E.4 Supply Option Preferences

Question 16 asked respondents to rank different options that water suppliers could undertake to improve future water supply reliability. There were 10 choices presented on the survey, including:

11. Increasing the amount of water that is imported from Northern California (from the Bay-Delta) or the Colorado River, and purchased from the Metropolitan Water District (MWD)
12. Increasing available supplies of water by transferring more water from agricultural uses in the state to Long Beach or MWD
13. Investing in desal facilities to convert ocean waters into part of the local potable supply
14. Increasing the price of water to residential, commercial, and industrial users so that they will use less
15. Requiring low-water-use landscaping in new homes and redevelopment projects (e.g., Xeriscape)
16. Increasing available supplies of water by expanding the import and use of non-local groundwater (i.e., water found underground and accessed by wells at locations some distance from Long Beach, and then pumped to the city)
17. Expanding the use of reclaimed water for outdoor irrigation and industrial uses
18. Using highly purified reclaimed water to replenish the local groundwater supply, allowing greater use of local groundwater

19. Promoting more voluntary water conservation through additional education and incentives (e.g., rebates to convert to low-water-use landscaping and water efficient appliances)
20. Increasing available supplies in dry years by acquiring more imported MWD water in wet years, and storing it underground for local use in dry years.

Respondents were asked to rank their top five most-preferred options. Figure 3 shows the percentage of respondents who selected a given option as one of their top three preferred choices. Five responses stand out as the preferred choices: expanding the use of reclaimed water for outdoor irrigation and industrial purposes; promoting more voluntary conservation through incentives and education; requiring low-water-use landscaping in new homes and redevelopment projects; using highly purified recycled water to replenish the groundwater supply; and investing in ocean desal facilities.

Question 16A asked respondents to choose their least preferred option of the remaining unranked choices. Figure 4 reveals that close to 30% of respondents chose increasing the price of water to residential, commercial, and industrial users so they will use less as their least preferred option. About 18% of respondents chose increasing supplies of water by importing water from northern California or the Colorado River as the water supply option they prefer the least.

In addition to the supply option preferences reflected above, we also asked specific questions about preferences for different versions of similar program options. For example, we asked respondents to indicate which of the two underground water storage options they preferred, and which of two water reuse options they preferred. Responses are summarized in Tables 12–16.

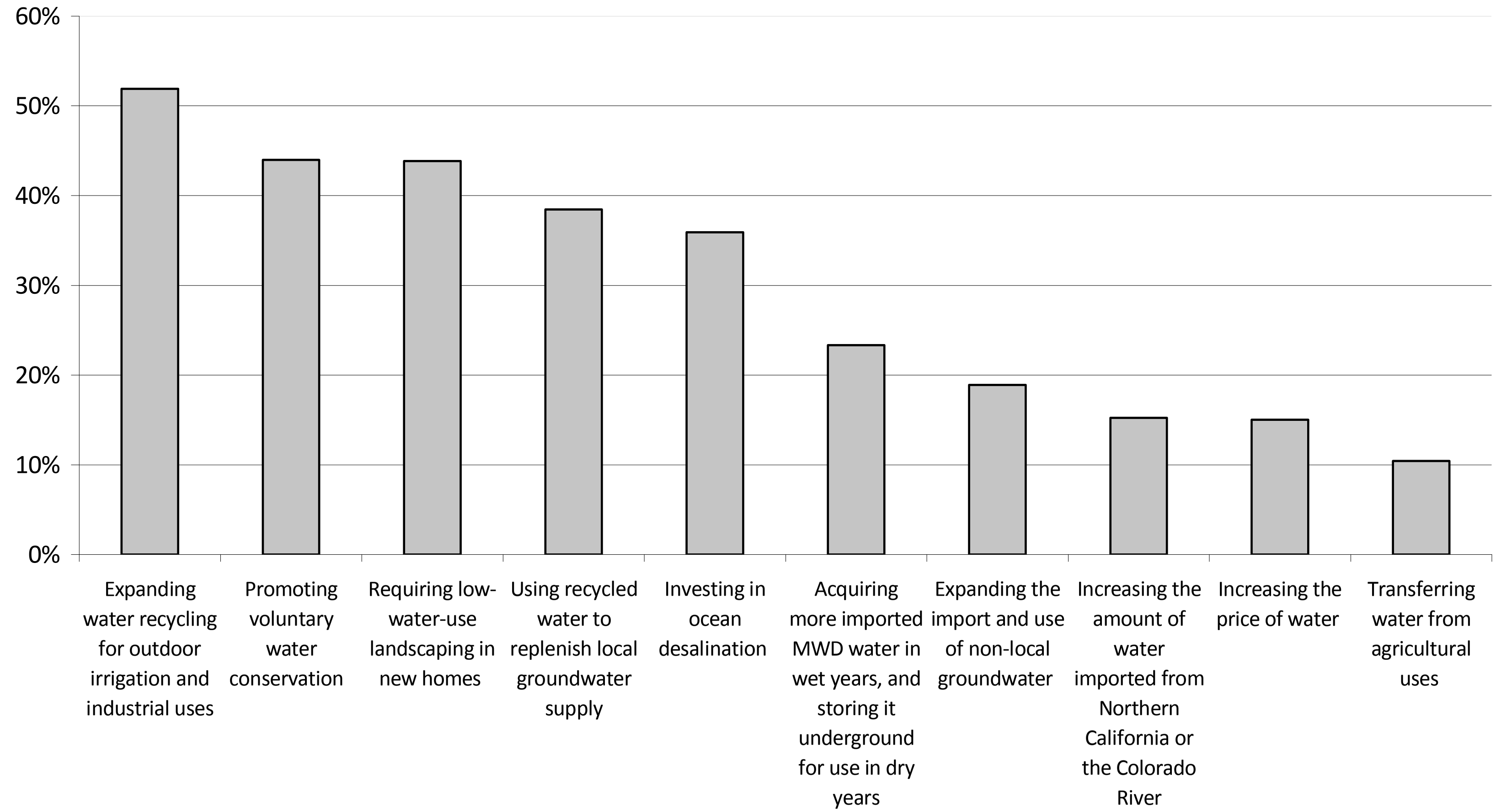



Figure 3. Percentage of respondents who selected a given option as one of their top three choices for dealing with future water shortages.

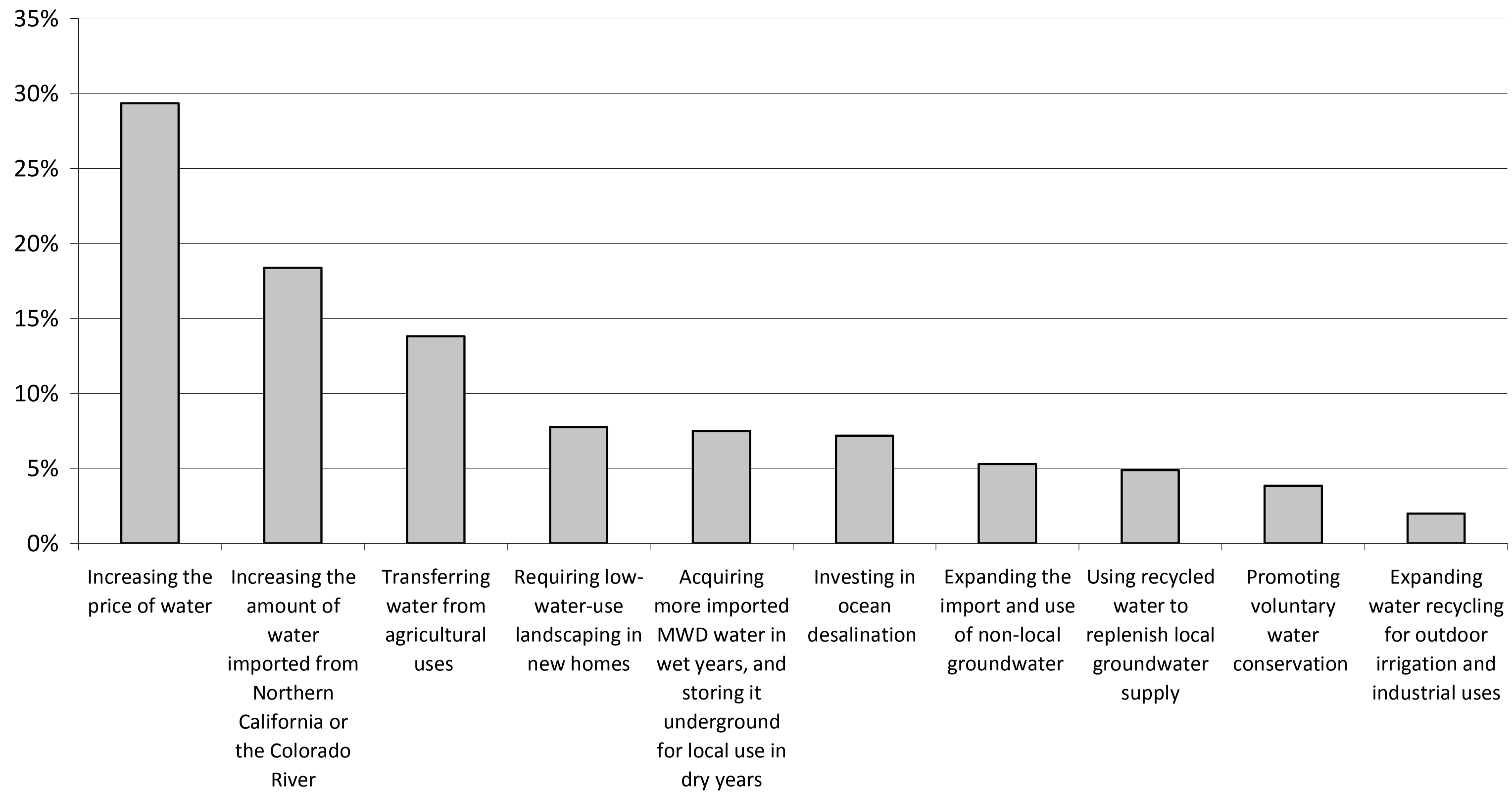



**Figure 4. Percentage of respondents who selected a given option as their least preferred option for dealing with future water shortages.**

**Table 12. Q17: Of the two underground water storage options below, which do you prefer?**

| | |
|---|---|
| Refused | 1.2% |
| Increasing underground storage of recycled water | 56.6% |
| Increasing underground storage of imported water in wet years | 42.3% |

**Table 13. Q17a: Of the two groundwater options below, which do you prefer?**

| | |
|---|---|
| Refused | 0.2% |
| Increasing use of local groundwater sources through replenishing the basin | 78.6% |
| Increasing use of non-local groundwater sources and pumping the water to | 21.2% |

**Table 14. Q18: Of the two water transfer and import options below, which do you prefer?**

| | |
|---|---|
| Refused | 0.04% |
| Increasing water imports from MWD | 58.1% |
| Increasing water transfers from agriculture | 41.9% |

**Table 15. Q19: Of the two water conservation options below, which do you prefer?**

| | |
|---|---|
| Refused | 0.04% |
| Requiring low-water-use landscaping in new homes | 51.6% |
| Promoting voluntary water conservation through education and incentives | 48.4% |

**Table 16. Q20: Of the two water recycling options below, which do you prefer?[a]**

| | |
|---|---|
| Refused | 0.6% |
| Expanding water recycling for outdoor irrigation and industrial uses | 36.6% |
| Expanding water recycling to replenish local groundwater supplies | 62.8% |

a. Note that because new piping is necessary for outdoor irrigation and industrial uses, expanding water recycling for outdoor irrigation and industrial uses costs three times as much as expanding water recycling to replenish reservoir supplies.

## E.5 Conditional Logit Model for Estimating WTP

Economists use a variety of models to analyze the type of data collected in the choice questions used in this survey. A well-accepted and straightforward model often applied is the conditional logit model. This model is used to estimate the probabilistic effect of a choice attribute or personal characteristic on the outcome of a given choice.

Since a respondent's choice is contingent on observed and random respondent characteristics, our model includes several variables to account for the variation in observed characteristics of a choice. We include the cost of the alternative associated with a given choice. We also define two attributes as the number of fewer restriction years relative to the status quo for each restriction level. Finally, we include personal characteristics, including education, age, income, a dummy variable indicating whether the respondent believes increasing water supplies is of high or low importance, the amount of time living in Long Beach, a dummy variable indicating yard ownership status, and a dummy variable indicating whether a respondent pays his or her own water bill. The personal characteristics are interacted with a dummy variable indicating whether the choice decision concerns an alternative to the status quo. This provides variability to the data and allows the model to estimate the impact of personal characteristics on choosing an alternative to the status quo.

Table 17 displays the results from the conditional logit model. The model uses 3,633 observations, an expansion of the 426 observations by nine choices (three choice questions and three choices per question), less 201 observations due to questions that were left unanswered by respondents.

As expected, cost has a negative impact on the likelihood of choosing a given option (i.e., as cost increases, the likelihood of choosing an alternative decreases). Age of the respondent is also found to have a negative impact on the likelihood of choosing a given option. Finally, respondents who feel that increasing water supplies is an important issue in their community are more likely to choose an alternative option. The other variables are not statistically significant from zero in the model estimated.

Note that the empirical conclusion above assumes a constant (i.e., linear) WTP for reductions in restriction years. Additional statistical analyses have been conducted to explore potential nonlinear effects of changes in restriction years on WTP (i.e., to explore whether the anticipated reduction in marginal WTP is observed as the number of avoided restrictions declines).

**Table 17. Conditional logit model for selecting an option as an alternative to the status quo (*n* = 3,633; log likelihood = -1,060.835)**

| Choice | Coefficient | Robust standard error | z | P > \|z\| | [95% confidence | interval] |
|---|---|---|---|---|---|---|
| Cost per year | -0.007 | 0.002 | -4.07 | 0.000 | -0.011 | -0.004 |
| Reduction in Level 1 restrictions[a] | -0.018 | 0.054 | -0.33 | 0.740 | -0.124 | 0.088 |
| Reduction in Level 2 restrictions | 0.255 | 0.090 | 2.85 | 0.004 | 0.079 | 0.431 |
| Chose alternative x education | 0.021 | 0.092 | 0.23 | 0.821 | -0.160 | 0.201 |
| Chose alternative × age | -0.313 | 0.098 | -3.20 | 0.001 | -0.504 | -0.121 |
| Chose alternative × income | 0.041 | 0.063 | 0.65 | 0.517 | -0.082 | 0.164 |
| Chose alternative × increasing water supplies important | 0.549 | 0.188 | 2.92 | 0.003 | 0.181 | 0.917 |
| Chose alternative × time living in Long Beach | -0.013 | 0.066 | -0.19 | 0.847 | -0.142 | 0.117 |
| Chose alternative × own yard | 0.018 | 0.234 | 0.08 | 0.938 | -0.440 | 0.477 |
| Chose alternative × pay water bill | -0.590 | 0.233 | -2.53 | 0.012 | -1.05 | -0.132 |

a. WTP to reduce Level 1 restrictions was not evaluated because it is assumed that Level 1 restrictions will remain permanently in place in the future.

Our more complex empirical analyses were aimed to better examine how the WTP estimates may be influenced by the total number of years of restrictions avoided (rather than assuming each year is valued equally, regardless of how many years in total have use restrictions eliminated). The results of our empirical evaluation (shown below) revealed no statistically significant difference between the linear results reported above and the nonlinear variations we estimated.

## E.6 WTP Measures

Using the parameter estimates from the conditional logit model in Section 5, we calculated WTP measures for reducing Level 1 and Level 2 restrictions. Table 18 presents the estimated mean WTP for a one-summer reduction in each restriction separately. As shown, the WTP estimate for reducing Level 1 restrictions is not statistically significant from zero. This means that respondents are not willing to pay to reduce Level 1 restrictions. The mean WTP for reducing Level 2 restrictions by 1 summer out of the next 20 years is positive and statistically significant from zero. These results imply a positive WTP by respondents for increasing water reliability to avoid Level 2 restrictions.

**Table 18. WTP estimates (*n* = 3,633)**

| Choice | Coefficient | Robust standard error | z | P > \|z\| | [95% confidence | interval] |
|---|---|---|---|---|---|---|
| WTP to reduce Level 1 restrictions by one summer out of the next 20 | -2.41 | 7.66 | -0.31 | 0.75 | -17.41 | 12.60 |
| WTP to reduce Level 2 restrictions by one summer out of the next 20 | 34.29 | 8.73 | 3.93 | 0.00 | 17.19 | 51.39 |
| WTP to avoid all restrictions | 102.86 | 26.18 | 3.93 | 0.00 | 51.56 | 154.17 |

a. WTP to avoid all restrictions assumes that WTP to reduce Level 1 restrictions by 1 summer out of the next 20 is $0.

To interpret these results in the context of understanding the mean household WTP for specific water supply enhancement programs, one needs to add the mean values based on the number and type of restrictions the program is expected to eliminate. For example, in the survey, the next 20 years were portrayed as yielding an anticipated eight summers with Level 1 restrictions, eight summers with Level 2 restrictions, and four summers with Level 3 restrictions. Suppose an ambitious supply enhancement program was expected to eliminate imposition of all of the projected Level 1 and Level 2 use restrictions. The mean annual WTP results above suggest that the total household WTP for this program would be ($0 × 10) + ($34.29 × 3) = $102.86 per year. This conclusion assumes a constant WTP for reductions in restriction years.

To gauge the strength of this assumption, we estimated several models with non-linear specifications. Using the best-fit non-linear model, the mean WTP for a program that eliminates the imposition of all projected Level 1 and Level 2 use restrictions = $104.18 (WTP to avoid Level 1 restrictions is not statistically significant from 0). This estimate is not statistically different from the estimate using the linear model. More generally, we find that the linear model underestimates WTP for smaller changes in summers with restrictions relative to the nonlinear models, and overestimates WTP for larger changes in summers with restrictions. However, in the range of reductions presented in the survey scenarios, the linear model provides a reliable average approximation of WTP for these scenarios.

# *Appendix F*

# Data Analysis of a Willingness to Pay Stated Choice Survey of Water Supply Reliability in the Orlando Area

## F.1 Introduction

Knowledge Networks (KN) administered the water supply reliability survey to 448 panelists within the Orlando Utilities Commission (OUC) service area from June 1, 2011 through June 20, 2011. KN administered the survey to 32 people on the KnowledgeNetwork™ Internet Panel; the remaining sample was supplemented using another Internet panel (e-Rewards). To ensure that all respondents received their water from the OUC, Stratus Consulting provided KN with a list of zip codes that were completely contained within the OUC service area.

Respondents were presented with three sets of choice questions near the end of the survey in order to evaluate their preferences for a range of possible programs to reduce (to varying degrees) different levels of water use restrictions over the next 20 years. Each choice set allowed respondents to choose the program called "No Additional Actions," which we refer to in this report as the "status quo." The experimental design for this study comprised 24 different programs with varying levels of use restrictions. For each choice set, KN randomly selected two of these programs. Once a program was selected in any of the choice questions for a given participant, it was not selected again in future choice questions (i.e., no replacement of programs). This allowed us to get three choice set data observations for each respondent.

The results presented in the following sections rely on 448 observations from Orlando, FL. Weights were generated by KN to adjust for sample design, non-coverage, and nonresponse biases. These weights were used in the analysis in order to generalize results to residents of specific zip codes who participated in the study.

The following sections present the results of this analysis. Section 2 presents how select respondent characteristics affected the likelihood of a respondent choosing an alternative to the status quo. This includes a summary of education, age, gender, income, ownership status of living quarters, work status, opinion on increasing water supplies, ownership status of yard, payment of water bill, and length of time living in Orlando. Section 3 presents the distribution of choices by version alternative. Sections 4, 5, and 6 provide more detailed empirical analysis of the data, including willingness to pay (WTP) estimates and respondent preferences for specific water supply options.

## F.2 Characteristics Predicting Choice Behavior

This section presents how select respondent characteristics affected the likelihood of choosing an alternative to the status quo. Since each respondent was asked three choice questions, there are multiple ways to define a binary choice variable that would indicate a respondent's choice for the status quo or an alternative. The most stringent definition – the one used for this analysis – requires a respondent to have chosen an alternative to the status quo in all three choice questions for this choice variable to take on a value of 1, and 0 otherwise. The following tables demonstrate how various respondent characteristics affected the outcome of this choice variable.

### F.2.1 Education

Table 1 shows that individuals with a bachelor's degree are more likely to choose an alternative to the status quo.

**Table 1. Education**

| Choice | Less than high school (*n* = 4; %) | High school (*n* = 34; %) | Some college (*n* = 154; %) | Bachelors (*n* = 256; %) |
|---|---|---|---|---|
| Status quo | 100 | 80.2 | 81.9 | 70.7 |
| Alternative | 0 | 19.8 | 18.1 | 29.3 |

### F.2.2 Age

Table 2 suggests that individuals over the age of 60 are much more likely to choose alternatives to the status quo in all three choice questions, compared to their younger counterparts. Individuals between the ages of 18 and 29 are the least likely to choose an alternative.

**Table 2. Age**

| Choice | 18–29 (*n* = 79; %) | 30–44 (*n* = 137; %) | 45–59 (*n* = 144; %) | 60 + (*n* = 88; %) |
|---|---|---|---|---|
| Status quo | 85.3 | 77.4 | 80.7 | 69.3 |
| Alternative | 14.7 | 22.6 | 19.3 | 30.7 |

### F.2.3 Gender

Table 3 demonstrates that males are slightly more likely to choose alternatives to the status quo than females.

**Table 3. Gender**

| Choice | Male (*n* = 173; %) | Female (*n* = 275; %) |
|---|---|---|
| Status quo | 77.5 | 79.1 |
| Alternative | 22.5 | 20.9 |

### F.2.4 Income

The decision to choose an alternative to the status quo seems to be influenced by income. Table 4 shows that individuals with household incomes of more than $50,000 are much more likely to choose alternatives to the status quo in all three choice questions compared to most of their counterparts. Individuals with household incomes of greater than $100,000 are most likely to choose alternatives.

**Table 4. Income (*n* = 405)**

| Choice | < $20,000 (*n* = 20; %) | $20,000–$29,999 (*n* = 39; %) | $30,000–$49,999 (*n* = 97; %) | $50,000–$74,999 (*n* = 99; %) | $75,000–$99,999 (*n* = 64; %) | > $100,000 (*n* = 105; %) |
|---|---|---|---|---|---|---|
| Status quo | 1. 77.7 | 79.5 | 86.5 | 73.7 | 74.5 | 69.6 |
| Alternative | 22.3 | 20.5 | 13.5 | 26.3 | 25.5 | 30.5 |

### F.2.5 Ownership status of living quarters

Table 5 reveals that respondents who own their living quarters are more likely to choose an alternative to the status quo compared to those rent their living quarters with payment. Respondents who do not pay for their living quarters are much less likely to choose alternatives to the status quo compared to both cash payment renters and owners.

**Table 5. Ownership status of living quarters (*n* = 424)**

| Choice | Owned or being bought by you or someone in your household (*n* = 309; %) | Rented for cash (*n* = 123; %) | Occupied without payment of cash rent (*n* = 16; %) |
|---|---|---|---|
| Status quo | 75.0 | 81.0 | 97.4 |
| Alternative | 25.1 | 19.0 | 2.6 |

### F.2.6 Work status

Work status appears to affect a respondent’s likelihood of choosing alternatives to the status quo in all three choice questions, as shown in Table 6. Respondents who are working as a paid employee or not working due to a temporary layoff from their job are less likely to choose an alternative to the status quo. Respondents who are not working due to a disability are much more likely to choose an alternative compared to all other respondents.

**Table 6. Work status**

| Choice | Working – as a paid employee ($n$ = 287; %) | Working – self-employed ($n$ = 38; %) | Not working – on temporary layoff from job ($n$ = 5; %) | Not working – looking for work ($n$ = 31; %) | Not working – retired ($n$ = 57; %) | Not working – disabled ($n$ = 9; %) | Not working – other ($n$ = 21; %) |
|---|---|---|---|---|---|---|---|
| Status quo | 81.4 | 73.4 | 87.3 | 77.9 | 70.2 | 34.6 | 77.8 |
| Alternative | 18.6 | 26.6 | 12.7 | 22.1 | 29.8 | 65.4 | 22.2 |

### F.2.7 Opinion on increasing water supplies

Question 2 of the survey asked respondents how important “increasing water supplies” is as an issue in the Orlando area. Respondents who answered “very” or “extremely” important were categorized as placing a high importance on increasing water supplies in their community. As shown in Table 7, these respondents are more likely to choose alternatives to the status quo in all three choice questions.

**Table 7. Opinion on increasing water supplies**

| Choice | Increasing water supplies low importance ($n$ = 202; %) | Increasing water supplies high importance ($n$ = 246; %) |
|---|---|---|
| Status quo | 80.8 | 76.6 |
| Alternative | 19.2 | 23.4 |

### F.2.8 Ownership status of yard

Table 8 shows that respondents who own a yard have a higher likelihood of choosing alternatives to the status quo across all three choice questions.

**Table 8. Ownership status of yard**

| Choice | Do not own yard ($n$ = 125; %) | Own yard ($n$ = 323; %) |
|---|---|---|
| Status quo | 82.5 | 76.5 |
| Alternative | 17.5 | 23.5 |

### F.2.9 Payment of water bill

Table 9 shows that a higher proportion of respondents who pay their own water bill chose alternatives to the status quo, compared to those who do not pay their own bill.

**Table 9. Payment of water bill**

| Choice | Does not pay own bill (*n* = 57; %) | Pays own bill (*n* = 389; %) |
|---|---|---|
| Status quo | 80.3 | 77.9 |
| Alternative | 19.7 | 22.1 |

### F.2.10 Time living in Orlando

Table 10 shows no clear relationship between the amount of time an individual has been living in Orlando and their likelihood of choosing an alternative to the status quo. Individuals who have been living in Orlando for less than one year are less likely to choose alternatives to the status quo in all three choice questions. Individuals that have lived in Orlando for 3 to 5 years are the most likely to choose an alternative to the status quo.

**Table 10. Time living in Orlando**

| Choice | Less than 1 year (*n* = 11; %) | 1–2 years (*n* = 24; % | 3–5 years (*n* = 54; %) | 6–10 years (*n* = 76; %) | More than 10 years (*n* = 283; %) |
|---|---|---|---|---|---|
| Status quo | 85.2 | 77.0 | 70.0 | 82.6 | 79.1 |
| Alternative | 14.8 | 23.0 | 30.0 | 17.4 | 20.9 |

## F.3 Distribution of Choices by Version Alternative

Table 11 and Figures 1 and 2 summarize the distribution of choices across the status quo, alternatives, and refusals. In Table 11, the column titled “Percentage chosen” displays the percentage of respondents who chose each version out of the respondents who were presented that version. For example, of the respondents who were presented Version 1, 9.66% chose Version 1 over the status quo and the other version presented. There are 1,344 observations underlying Table 11 as each of the 448 respondents were asked three choice questions. Although this analysis does not address the variation of alternative versions presented to respondents, Table 11 and Figures 1 and 2 provide feedback about respondent responses to each alternative version. More than half of the responses were refusals or choices for the status quo (64.4%).

**Table 11. Distribution of choices by version alternative (*n* = 1,344)**

| Version | Summers with Level 1 restrictions | Summers with Level 2 restrictions | Summers with Level 3 restrictions | Cost per year | Cost per month | Percentage chosen |
|---|---|---|---|---|---|---|
| Refused | | | | | | 1.24 |
| Status quo | 7 | 10 | 3 | 12 | 1 | 63.2 |
| 1 | 11 | 8 | 1 | 160 | 13 | 9.66 |
| 2 | 12 | 6 | 2 | 95 | 8 | 28.53 |
| 3 | 13 | 5 | 2 | 210 | 18 | 13.65 |
| 4 | 15 | 5 | 0 | 300 | 25 | 19.16 |
| 5 | 10 | 8 | 2 | 60 | 5 | 37.15 |
| 6 | 11 | 6 | 3 | 130 | 11 | 3.81 |
| 7 | 13 | 7 | 0 | 240 | 20 | 12.25 |
| 8 | 15 | 4 | 1 | 290 | 24 | 11.04 |
| 9 | 12 | 5 | 3 | 90 | 8 | 31.48 |
| 10 | 12 | 8 | 0 | 110 | 9 | 17.54 |
| 11 | 9 | 8 | 3 | 65 | 5 | 16.27 |
| 12 | 14 | 6 | 0 | 150 | 13 | 14.53 |
| 13 | 13 | 6 | 1 | 220 | 18 | 10.10 |
| 14 | 11 | 7 | 2 | 150 | 13 | 8.16 |
| 15 | 8 | 9 | 3 | 20 | 2 | 26.32 |
| 16 | 10 | 7 | 3 | 55 | 5 | 21.83 |
| 17 | 14 | 4 | 2 | 130 | 11 | 12.39 |
| 18 | 14 | 5 | 1 | 140 | 12 | 17.52 |
| 19 | 13 | 4 | 3 | 200 | 17 | 5.76 |
| 20 | 12 | 7 | 1 | 100 | 8 | 19.22 |
| 21 | 11 | 9 | 0 | 170 | 14 | 13.47 |
| 22 | 16 | 4 | 0 | 180 | 15 | 18.87 |
| 23 | 9 | 9 | 2 | 80 | 7 | 18.44 |
| 24 | 10 | 9 | 1 | 65 | 5 | 30.08 |

Figures 1 and 2 show the distribution of choices by the cost of each alternative (Figure 1) as well as the distribution of choices by the number of fewer restriction years[24] (Figure 2). Based on these figures, program cost seems to play a larger role in

19. [24] The number of fewer Level 2 restriction years was assigned a weight of 3 to represent the significance respondents placed on reducing Level 2 restrictions compared to Level 1 restrictions, which are much less severe.

the decision to choose an alternative than the number of fewer restriction years that the alternative offers. The figures illustrate that the correlation between program cost and the percentage of time an alternative was chosen (when it was presented to respondents) was 0.28. This is compared to a correlation of 0.004 between the percentage of time an alternative was chosen and the number of fewer restriction years the alternative would provide.

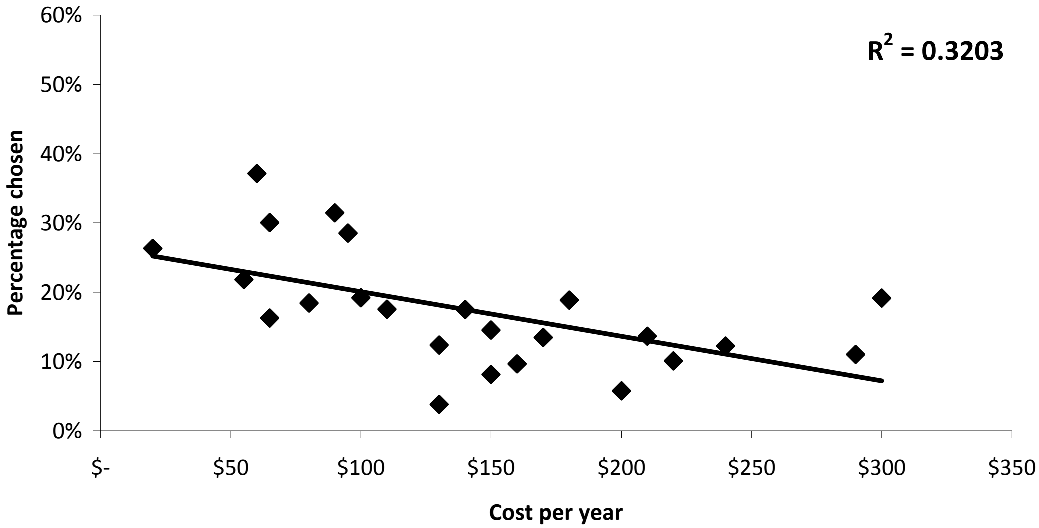



**Figure 1. Distribution of choices by program cost.**

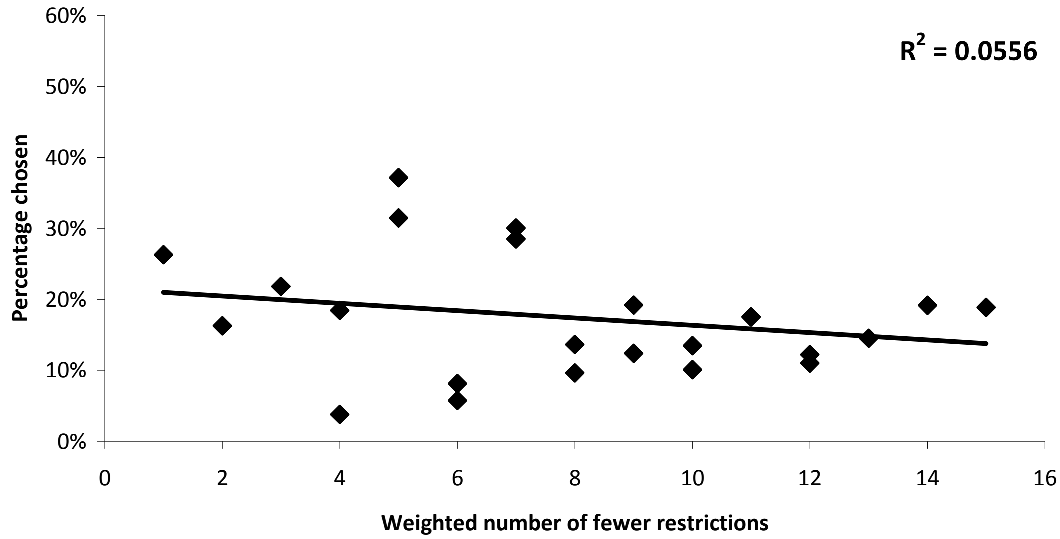



**Figure 2. Distribution of choices by number of (weighted) fewer restriction years.**

## F.4 Supply Option Preferences

Question 16 asked respondents to rank different options that water suppliers could undertake to improve the future water supply reliability. There were 10 choices presented in the survey, including:

21. Increasing available supplies by diverting and storing surface water from the St. Johns River in reservoirs, and using these surface waters as part of the potable water supply
22. Investing in desal facilities to convert ocean waters into part of the local potable water supply
23. Investing in desal facilities to convert brackish groundwater near the east coast of Florida into part of the Orlando region's local potable water supply
24. Increasing the price of water to residential, commercial, and industrial users so that they will use less
25. Requiring low-water-use landscaping (e.g., Florida Friendly landscaping) in new homes and redevelopment projects
26. Expanding the use of recycled water for outdoor irrigation and industrial uses
27. Increasing the use of local groundwater sources
28. Using highly purified recycled water to replenish the local groundwater supply, allowing greater use of local groundwater
29. Increasing available supplies by diverting surface water from the St. Johns River and storing it underground, allowing greater use of local groundwater
30. Promoting more voluntary water conservation through additional education and incentives (e.g., rebates to convert to low-water-use landscaping and water efficient appliances).

Respondents were asked to rank their top five most-preferred options. Figure 3 shows the percentage of respondents who selected the given options as one of their top three most-preferred choices.

Three responses stand out as the preferred choices: expanding the use of recycled water for outdoor irrigation and industrial uses; requiring low-water-use landscaping in new homes and redevelopment projects; and promoting more voluntary water conservation through additional education and incentives. Using highly purified recycled water to replenish the local groundwater supply was also a relatively popular option.

Question 16A of the survey asked respondents to choose their least preferred option of the remaining unranked choices. Figure 4 reveals that more than 40% of respondents chose increasing the price of water to residential, commercial, and industrial users as their least preferred option.

In addition to the supply option preferences reflected above, we also asked specific questions about preferences for different versions of similar program options. For example, we asked respondents to indicate which of two underground water storage options they preferred, which of two groundwater options they preferred, which of two water import options they preferred, which of two water conservation options they preferred, and which of two water recycling options they preferred. Responses are summarized in Tables 12–16.

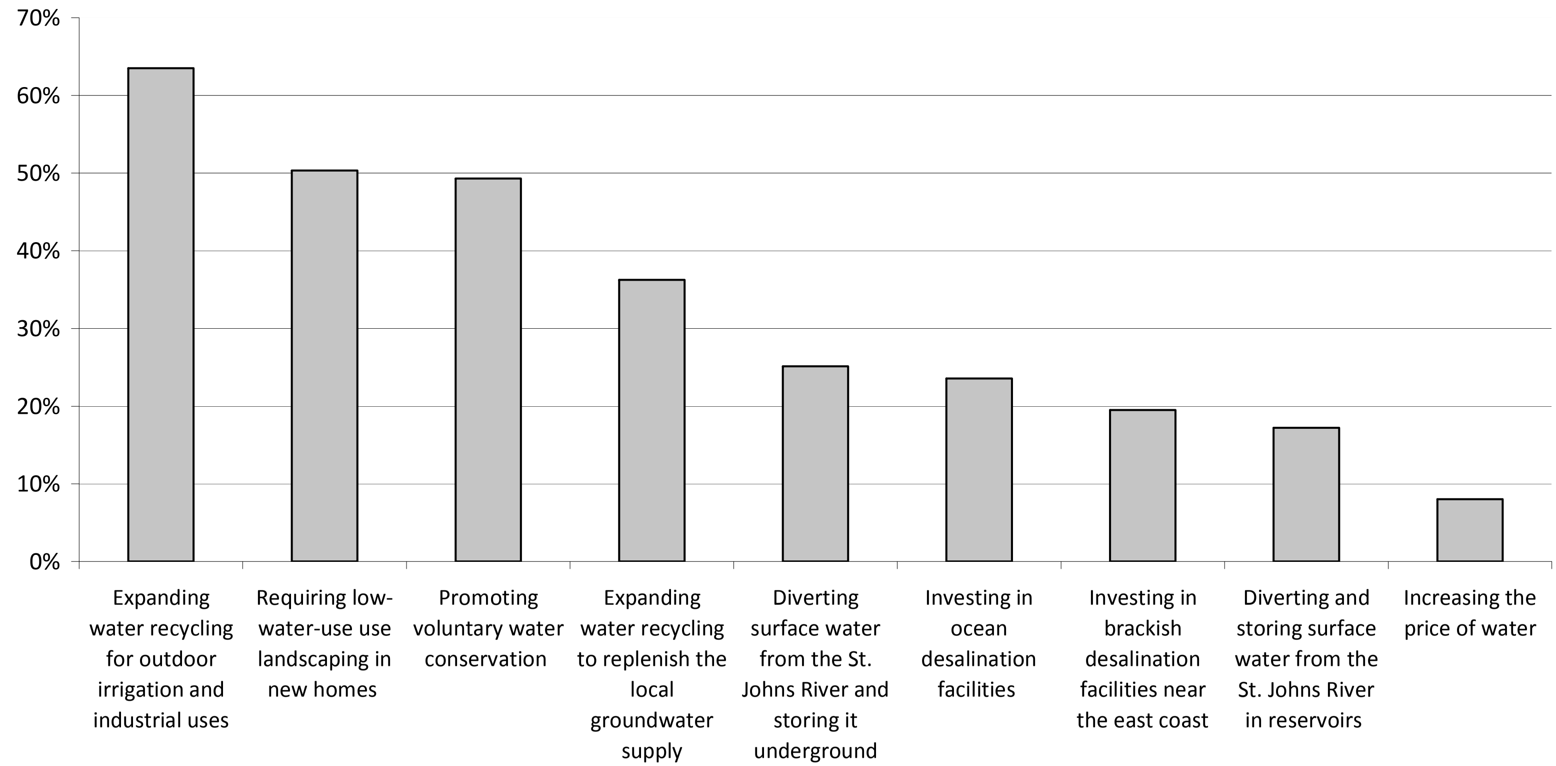



**Figure 3. Percentage of respondents who selected a given option as one of their top three choices for dealing with future water shortages**.

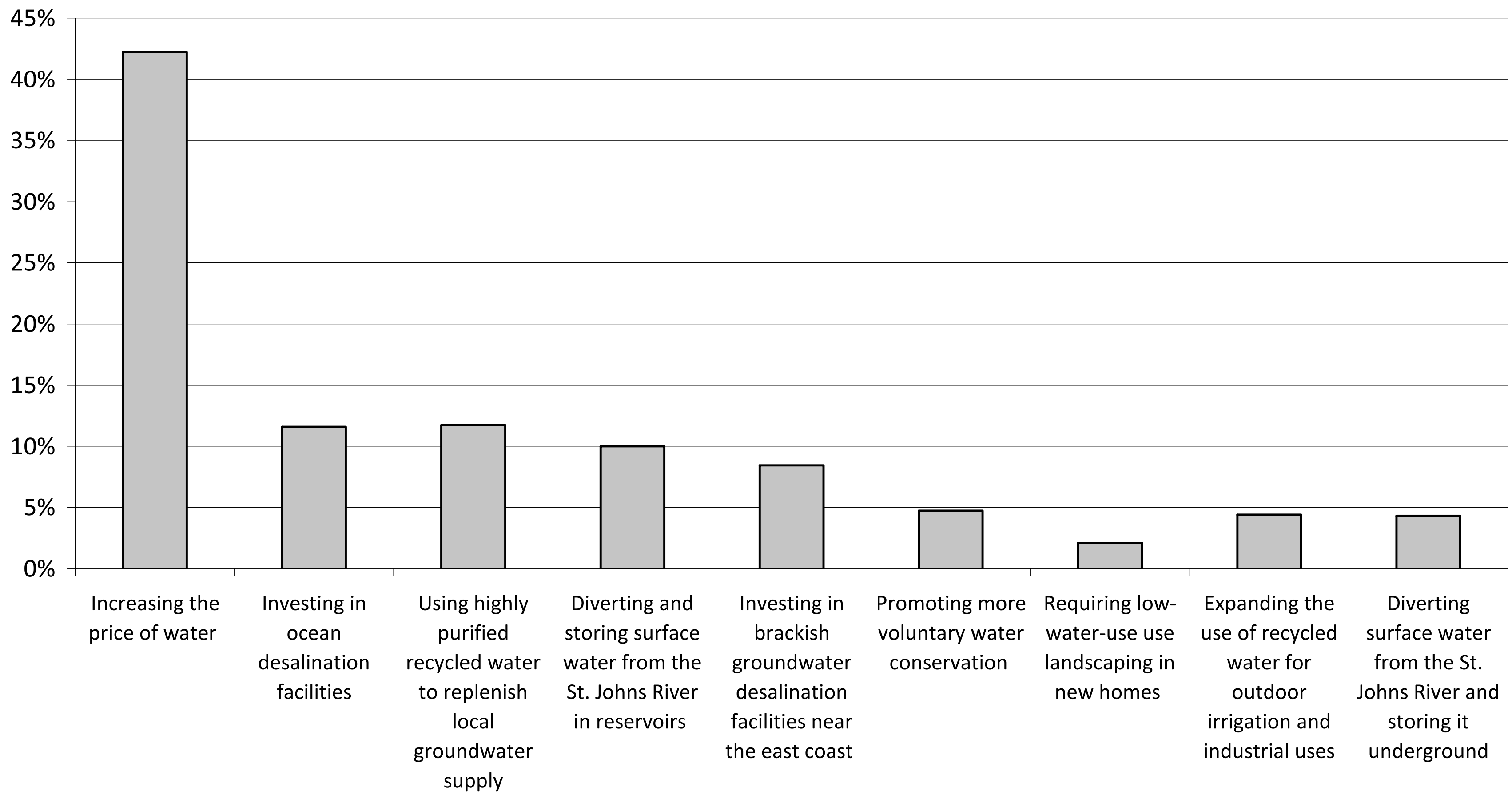



**Figure 4. Percentage of respondent who selected a given option as their *least* preferred option for dealing with future water shortages.**

**Table 12. Q17: Of the two underground water storage options below, which do you prefer?**

| | |
|---|---|
| Refused | 0.6% |
| Increasing underground storage of recycled water every year | 60.3% |
| Increasing underground storage of local or imported surface water in wet years | 39.1% |

**Table 13. Q18: Of the two groundwater options below, which do you prefer?**

| | |
|---|---|
| Refused | 0.4% |
| Increasing the use of local groundwater sources by storing recycled or river water underground | 80.2% |
| Increasing use of non-local groundwater sources and pumping the water to Orlando | 19.5% |

**Table 14. Q19: Of the two water import options below, which do you prefer?**

| | |
|---|---|
| Refused | 0.4% |
| Importing water from the St. John's River and storing it in surface water reservoirs | 53.6% |
| Importing and treating brackish groundwater from Florida's east coast | 46.0% |

2.

**Table 15. Q20: Of the two water conservation options below, which do you prefer?**

| | |
|---|---|
| Refused | 0.4% |
| Requiring low-water-use landscaping in new homes | 55.2% |
| Promoting additional voluntary water conservation through education and incentives | 44.0% |

3.

**Table 16. Q21: Of the two water recycling options below, which do you prefer?[a]**

| | |
|---|---|
| Refused | 0.4% |
| Expanding water recycling for outdoor irrigation and industrial uses | 55.5% |
| Expanding water recycling to replenish local groundwater supplies | 44.2% |

a. Note that respondents were informed that because new piping is necessary for outdoor irrigation and industrial uses, expanding water recycling for outdoor irrigation and industrial uses costs three times as much as expanding water recycling to replenish reservoir supplies.

Finally, to explore how OUC customers feel about specific options, respondents were asked about their perceptions regarding the quality of water supplied to them from various water sources for different uses**.** As shown in Table 17, customers rated the quality of water supplied from most sources as “Moderately good.” Respondents seem to be a little more skeptical of desal of seawater or brackish water. About 32.3% of respondents rated the quality of desalinated seawater for drinking water as “slightly good” or “not good at all.” Approximately 37.1% of respondents rated the quality of desalinated brackish groundwater as “slightly good” or “not good at all.” Respondents seem to be the most comfortable with the quality of fresh groundwater use, with 15.8% rating the quality of this source as “extremely good.”

**Table 17. OUC customer preferences for various local options and uses**

| Water source | Water use | Not good at all (%) | Slightly good (%) | Moderately good (%) | Very good (%) | Extremely good (%) | Refused (%) |
|---|---|---|---|---|---|---|---|
| Increasing fresh groundwater use | Drinking water | 6.0 | 12.0 | 34.7 | 31.5 | 15.8 | |
| Diverting water from the St. Johns River to storage reservoirs | Drinking water | 3.7 | 18.7 | 49.8 | 24.1 | 3.7 | |
| Storing river water underground when plentiful and withdrawing the water when needed | Drinking water | 4.8 | 14.1 | 42.7 | 31.3 | 7.1 | |
| Adding desalinated seawater from the Atlantic Ocean | Drinking water | 10.3 | 22.0 | 39.4 | 22.4 | 5.7 | 0.3 |
| Adding desalinated brackish groundwater from wells near the east coast | Drinking water | 14.2 | 22.9 | 38.8 | 21.0 | 2.8 | 0.4 |
| Storing recycled water underground when plentiful and withdrawing the water when needed | Drinking water | 11.6 | 17.3 | 37.6 | 26.3 | 6.9 | 0.4 |
| Increasing the use of recycled water | Irrigation and industrial uses | 7.9 | 14.8 | 39.7 | 27.5 | 10.1 | |

## F.5 Conditional Logit Model for Estimating WTP

Economists use a variety of models to analyze the type of data collected in the choice questions used in this survey. A well-accepted and straightforward model often applied is the conditional logit model. This model is used to estimate the probabilistic effect of a choice attribute or personal characteristic on the outcome of a given choice.

Since a respondent’s choice is contingent on observed and random respondent characteristics, our model includes several variables to account for the variation in observed characteristics of a choice. We include the cost of the alternative associated with a given choice. We also define two attributes as the number of fewer restriction years relative to the status quo for each restriction level. Finally, we include personal characteristics, including education, age, income, a dummy variable indicating whether the respondent believes increasing water supplies is of high or low importance, the amount of time a respondent has lived in Orlando, a dummy variable indicating yard ownership status, and a dummy variable indicating whether a respondent pays his or her own water bill. The personal characteristics are interacted with a dummy variable indicating whether the choice decision concerns an alternative to the status quo. This provides variability to the data and allows the model to estimate the impact of personal characteristics on choosing an alternative to the status quo.

Table 18 displays the results from the conditional logit model. The model uses 3,813 observations, an expansion of the 448 observations by nine choices (three choice questions and three choices per question), less 219 observations due to questions that were left unanswered by respondents.

**Table 18. Conditional logit model for selecting an option as an alternative to the status quo (*n* = 3,813; log likelihood = -1,086.27)**

| Choice | Coefficient | Robust standard error | z | P > \|z\| | [95% confidence | interval] |
|---|---|---|---|---|---|---|
| Cost per year | -0.009 | 0.002 | -3.440 | 0.001 | -0.013 | -0.004 |
| Reduction in level 1 restrictions | 0.078 | 0.060 | 1.290 | 0.198 | -0.041 | 0.196 |
| Reduction in level 2 restrictions | 0.173 | 0.085 | 2.040 | 0.042 | 0.006 | 0.340 |
| Chose alternative × education | -0.083 | 0.114 | -0.730 | 0.465 | -0.306 | 0.140 |
| Chose alternative × age | 0.054 | 0.103 | 0.530 | 0.597 | -0.147 | 0.256 |
| Chose alternative × income | 0.205 | 0.081 | 2.540 | 0.011 | 0.046 | 0.363 |
| Chose alternative × increasing water supplies important | 0.236 | 0.204 | 1.150 | 0.248 | -0.165 | 0.636 |
| Chose alternative × time living in Orlando | -0.285 | 0.086 | -3.330 | 0.001 | -0.453 | -0.117 |
| Chose alternative × own yard | 0.200 | 0.286 | 0.700 | 0.485 | -0.361 | 0.761 |
| Chose alternative × pay water bill | -0.471 | 0.328 | -1.440 | 0.150 | -1.113 | 0.171 |

As expected, cost has a negative impact on the likelihood of choosing a given option (i.e., as cost increases, the likelihood of choosing an alternative decreases). The amount of time an individual has lived in Orlando is also found to have a negative impact on the likelihood of choosing a given option. Household income seems to have a positive impact on the likelihood of choosing an alternative option (i.e., as household income increases, the likelihood of choosing an alternative increases). The number of fewer Level 2 restriction years relative to the status quo also has a positive impact on the likelihood of choosing an alternative (i.e., people are willing to pay more to avoid a greater number of Level 2 restrictions). The other variables are not statistically significant from zero in the model estimated.

Note that the empirical conclusion above assumes a constant (i.e., linear) WTP for reductions in restriction years. Additional statistical analyses have been conducted to explore potential non-linear effects of changes in restriction years on WTP (i.e., to explore whether the anticipated reduction in marginal WTP is observed as the number of avoided restrictions declines). The more complex empirical analyses were aimed to better examine how the WTP estimates may be influenced by the total number of years of restrictions avoided (rather than assuming each year is valued equally, regardless of how many years in total have use restrictions eliminated). The results of our empirical evaluation (shown below) revealed no statistically significant difference between the linear results reported above and the non-linear variations we estimated.

## F.6 WTP Measures

Using the parameter estimates from the conditional logit model in Section 5, we calculated WTP measures for reducing Level 1 and Level 2 restrictions. Table 19 presents the estimated mean WTP for a one-summer reduction in each restriction separately. As shown, the WTP estimate for reducing Level 1 restrictions is not statistically significant than zero. This result implies that OUC customers are not willing to pay to reduce Level 1 restrictions. The mean WTP for reducing Level 2 restrictions by 1 summer out of the next 20 years is positive and statistically significant from zero. This implies a positive WTP by respondents for increasing water reliability to avoid Level 2 restrictions.

**Table 19. WTP estimates (*n* = 3,813)**

| Choice | Coefficient | Robust standard error | z | P > \|z\| | [95% confidence interval] | |
|---|---|---|---|---|---|---|
| WTP to reduce Level 1 restrictions by 1 summer out of the next 20 | 9.05 | 5.63 | 4. 1.61 | 0.11 | -2.00 | 20.09 |
| WTP to reduce Level 2 restrictions by 1 summer out of the next 20 | 20.20 | 7.87 | 2.57 | 0.01 | 4.77 | 35.63 |
| WTP to avoid all restrictions | 151.09 | 63.39 | 2.38 | 0.02 | 26.85 | 275.34 |

To interpret these results in the context of understanding the mean household WTP for specific water supply enhancement programs, one needs to add the mean values based on the number and type of restrictions the program is expected to eliminate. For example, in the survey, the next 20 years were portrayed as yielding an anticipated eight summers with Level 1 restrictions, eight summers with Level 2 restrictions, and four summers with Level 3 restrictions. Suppose an ambitious supply enhancement program was expected to eliminate imposition of all of the projected Level 1 and Level 2 use restrictions. The mean annual WTP results above suggest that the total household WTP for this program would be ($9.05 × 10) + ($20.20 × 3) = $151.09 per year. This conclusion assumes a constant WTP for reductions in restriction years.

To gauge the strength of this assumption, we estimated several models with nonlinear specifications. In general, we find that the linear model underestimates WTP for smaller changes in summers with restrictions relative to the nonlinear models, and overestimates WTP for larger changes in summers with restrictions. However, in the range of reductions presented in the survey scenarios, the linear model provides a reliable average approximation of WTP for these scenarios.

*Appendix G*

# Data Analysis of a Willingness to Pay Stated Choice Survey of Water Supply Reliability in the San Francisco Area

## G.1 Introduction

Knowledge Networks (KN) administered the water supply reliability survey to 417 panelists within the San Francisco Public Utilities Commission (SFPUC) service area from April 8, 2011 through April 23, 2011. KN administered the survey to 80 people on the KnowledgeNetwork™ Internet Panel; the remaining sample was supplemented using another Internet panel (e-Rewards). To ensure that all respondents received their water from the City of San Francisco, Stratus Consulting provided KN with a list of zip codes that were completely contained within the SFPUC service area.

Respondents were presented with three sets of choice questions near the end of the survey in order to evaluate their preferences for a range of possible programs to reduce (to varying degrees) different levels of water use restrictions over the next 20 years. Each choice set allowed respondents to choose the program called "No Additional Actions," which we refer to in this report as the "status quo." The experimental design for this study comprised 24 different programs with varying levels of use restrictions. For each choice set, KN randomly selected two of these programs. Once a program was selected in any of the choice questions for a given participant, it was not selected again in future choice questions (i.e., no replacement of programs). This allowed us to get three choice set data observations for each respondent.

The results presented in the following sections rely on 417 observations from San Francisco, California. Weights were generated by KN to adjust for sample design, non-coverage, and nonresponse biases. These weights were used in the analysis in order to generalize results to residents of specific zip codes who participated in the study.

The following sections present the results of this analysis. Section 2 presents how select respondent characteristics affected the likelihood of a respondent choosing an alternative to the status quo. This includes a summary of education, age, gender, income, ownership status of living quarters, work status, opinion on increasing water supplies, ownership status of yard, payment of water bill, and length of time living in San Francisco. Section 3 presents the distribution of choices by version alternative. Sections 4, 5, and 6 provide more detailed empirical analysis of the data, including willingness to pay (WTP) estimates and respondent preferences for specific water supply options.

## G.2 Characteristics Predicting Choice Behavior

This section presents how select respondent characteristics affected the likelihood of choosing an alternative to the status quo. Since each respondent was asked three choice questions, there are multiple ways to define a binary choice variable that would indicate a respondent's choice for the status quo or an alternative. The most stringent definition – the one used for this analysis – requires a respondent to have chosen an alternative to the status quo in all three choice questions for this choice variable to take on a value of 1, and 0 otherwise. The following tables demonstrate how various respondent characteristics affected the outcome of this choice variable.

### G.2.1 Education

Table 1 demonstrates no clear relationship between education level and the likelihood of choosing alternatives to the status quo in all three choice questions. The table shows that individuals with a high school diploma are much more likely to choose an alternative to the status quo. However, a very small number of respondents fall into this category; thus, it is difficult to draw specific conclusions about this group.

**Table 1. Education**

| Choice | Less than high school (*n* = 2; %) | High school (*n* = 6; %) | Some college (*n* = 77; %) | Bachelors (*n* = 332; %) |
|---|---|---|---|---|
| Status quo | 69.0 | 26.9 | 78.1 | 59.7 |
| Alternative | 31.0 | 73.1 | 21.9 | 40.3 |

### G.2.2 Age

Table 2 suggests that individuals under the age of 30 are much more likely to choose alternatives to the status quo in all three choice questions, compared to their older counterparts.

**Table 2. Age**

| Choice | 18–29 (*n* = 35; %) | 30–44 (*n* = 139; %) | 45–59 (*n* = 127; %) | 60 + (*n* = 116; %) |
|---|---|---|---|---|
| Status quo | 39.3 | 66.4 | 67.8 | 67.5 |
| Alternative | 60.7 | 33.6 | 32.2 | 32.5 |

### G.2.3 Gender

Table 3 demonstrates that males are more likely to choose alternatives to the status quo than females.

**Table 3. Gender**

| Choice | Male ($n$ = 203; %) | Female ($n$ = 214; %) |
|---|---|---|
| Status quo | 61.7 | 68.0 |
| Alternative | 38.3 | 32.0 |

### G.2.4 Income

Table 4 shows that individuals with household incomes of between $50,000 and $74,999 are slightly more likely to choose alternatives to the status quo in all three choice questions compared to most of their counterparts. Individuals with household incomes between $20,000 and $29,000 are much less likely to choose alternatives (however, only 14 respondents fall into this category). Overall, the decision to choose an alternative to the status quo does not seem to be heavily influenced by income.

**Table 4. Income**

| Choice | < $20,000 ($n$ = 24; %) | $20,000–$29,999 ($n$ = 14; %) | $30,000–$49,999 ($n$ = 35; %) | $50,000–$74,999 ($n$ = 81; %) | $75,000–$99,999 ($n$ = 83; %) | > $100,000 ($n$ = 180; %) |
|---|---|---|---|---|---|---|
| Status quo | 5. 63.0 | 81.9 | 63.5 | 58.2 | 64.9 | 65.4 |
| Alternative | 37.0 | 18.1 | 36.5 | 41.8 | 35.2 | 34.7 |

### G.2.5 Ownership status of living quarters

Table 5 reveals that respondents who rent their living quarters with payment are more likely to choose an alternative to the status quo compared to those who own their living quarters. Respondents who do not pay for their living quarters are less likely to choose alternatives to the status quo compared to both cash payment renters and owners.

**Table 5. Ownership status of living quarters**

| Choice | Owned or being bought by you or someone in your household ($n$ = 227; %) | Rented for cash ($n$ = 176; %) | Occupied without payment of cash rent ($n$ = 14; %) |
|---|---|---|---|
| Status quo | 67.3 | 60.3 | 81.0 |
| Alternative | 32.7 | 39.7 | 19.0 |

### G.2.6 Work status

Work status appears to affect a respondent's likelihood of choosing alternatives to the status quo in all three choice questions, as shown in Table 6. Respondents who are self-employed, not working due to a temporary layoff from their job, or not working due to other reasons, are less likely to choose an alternative to the status quo. Respondents who are not working due to a disability are much more likely to choose an alternative compared to all other respondents.

**Table 6. Work status**

| Choice | Working – as a paid employee (*n* = 247; %) | Working – self-employed (*n* = 48; %) | Not working – on temporary layoff from job (*n* = 4; %) | Not working – looking for work (*n* = 25; %) | Not working – retired (*n* = 67; %) | Not working – disabled (*n* = 9; %) | Not working – other (*n* = 17; %) |
|---|---|---|---|---|---|---|---|
| Status quo | 63.6 | 73.4 | 100 | 60.6 | 62.3 | 33.9 | 81.9 |
| Alternative | 36.4 | 26.6 | 0 | 39.4 | 37.7 | 66.1 | 18.1 |

### G.2.7 Opinion on increasing water supplies

Question 2 of the survey asked respondents how important "increasing water supplies" is as an issue in the San Francisco area. As shown in Table 7, respondents who answered "very" or "extremely" important to Question 2 are surprisingly less likely to choose alternatives to the status quo in all three choice questions.

**Table 7. Opinion on increasing water supplies**

| Choice | Increasing water supplies low importance (*n* = 74; %) | Increasing water supplies high importance (*n* = 180; %) |
|---|---|---|
| Status quo | 63.8 | 66.1 |
| Alternative | 36.2 | 33.9 |

### G.2.8 Ownership status of yard

Table 8 shows that respondents who do not own a yard have a higher likelihood of choosing alternatives to the status quo across all three choice questions.

**Table 8. Ownership status of yard**

| Choice | Do not own yard (*n* = 198; %) | Own yard (*n* = 219; %) |
|---|---|---|
| Status quo | 59.5 | 69.7 |
| Alternative | 40.5 | 35.3 |

### G.2.9 Payment of water bill

Table 9 shows that a lower proportion of respondents who pay their own water bill chose alternatives to the status quo, compared to those who do not pay their own bill.

**Table 9. Payment of water bill**

| Choice | Does not pay own bill ($n$ = 214; %) | Pays own bill ($n$ = 200; %) |
|---|---|---|
| Status quo | 60.4 | 69.5 |
| Alternative | 39.6 | 30.5 |

### G.2.10 Time living in San Francisco

Table 10 shows that individuals who have been living in San Francisco for less than one year are less likely to choose alternatives to the status quo in all three choice questions. However, it is difficult to draw conclusions about the relationship between the amount of time a respondent has been living in San Francisco and the likelihood of choosing an alternative to the status quo because the sub-populations for some categories are very small (i.e., only 2 respondents have been living in San Francisco for less than 1 year, and 4 have been living in San Francisco for 1 to 2 years). The majority of respondents sampled (333 or 80%) have been living in San Francisco for more than 10 years.

**Table 10. Time living in San Francisco**

| Choice | Less than 1 year ($n$ = 2; %) | 1–2 years ($n$ = 4; %) | 3–5 years ($n$ = 29; %) | 6–10 years ($n$ = 49; %) | More than 10 years ($n$ = 333; %) |
|---|---|---|---|---|---|
| Status quo | 75.6 | 48.8 | 43.8 | 50.6 | 68.9 |
| Alternative | 24.4 | 51.2 | 28.0 | 49.4 | 31.1 |

## G.3 Distribution of Choices by Version Alternative

Table 11 and Figures 1 and 2 summarize the distribution of choices across the status quo, alternatives, and refusals. In Table 11, the column titled “Percentage chosen” displays the percentage of respondents who chose each version out of the respondents who were presented that version. For example, of the respondents who were presented Version 1, 21.4% chose Version 1 over the status quo and the other version presented. There are 1,251 observations underlying Table 11 as each of the 417 respondents were asked three choice questions. Although this analysis does not address the variation of alternative versions presented to respondents, Table 11 and Figures 1 and 2 provide feedback about respondent responses to each alternative version. More than half of the responses were refusals or choices for the status quo (53.1%). The remaining responses were allocated across alternatives to the status quo.

**Table 11. Distribution of choices by version alternative ($n$ = 1,251)**

| Version | Summers with Level 1 restrictions | Summers with Level 2 restrictions | Summers with Level 3 restrictions | Cost per year | Cost per month | Percentage chosen |
|---|---|---|---|---|---|---|
| Refused | | | | | | 2.4 |
| Status quo | 7 | 10 | 3 | 12 | 1 | 50.7 |
| 1 | 11 | 8 | 1 | 160 | 13 | 21.4 |
| 2 | 12 | 6 | 2 | 95 | 8 | 38.1 |
| 3 | 13 | 5 | 2 | 210 | 18 | 16.7 |
| 4 | 15 | 5 | 0 | 300 | 25 | 9.1 |
| 5 | 10 | 8 | 2 | 60 | 5 | 36.5 |
| 6 | 11 | 6 | 3 | 130 | 11 | 10.5 |
| 7 | 13 | 7 | 0 | 240 | 20 | 18.7 |
| 8 | 15 | 4 | 1 | 290 | 24 | 8.6 |
| 9 | 12 | 5 | 3 | 90 | 8 | 28.8 |
| 10 | 12 | 8 | 0 | 110 | 9 | 39.6 |
| 11 | 9 | 8 | 3 | 65 | 5 | 19.8 |
| 12 | 14 | 6 | 0 | 150 | 13 | 36.5 |
| 13 | 13 | 6 | 1 | 220 | 18 | 12.4 |
| 14 | 11 | 7 | 2 | 150 | 13 | 21.4 |
| 15 | 8 | 9 | 3 | 20 | 2 | 25.0 |
| 16 | 10 | 7 | 3 | 55 | 5 | 29.0 |
| 17 | 14 | 4 | 2 | 130 | 11 | 20.5 |
| 18 | 14 | 5 | 1 | 140 | 12 | 21.4 |
| 19 | 13 | 4 | 3 | 200 | 17 | 14.9 |

**Table 11. Distribution of choices by version alternative ($n$ = 1,251) (cont.)**

| Version | Summers with Level 1 restrictions | Summers with Level 2 restrictions | Summers with Level 3 restrictions | Cost per year | Cost per month | Percentage chosen |
|---|---|---|---|---|---|---|
| 20 | 12 | 7 | 1 | 100 | 8 | 34.7 |
| 21 | 11 | 9 | 0 | 170 | 14 | 21.3 |
| 22 | 16 | 4 | 0 | 180 | 15 | 26.8 |
| 23 | 9 | 9 | 2 | 80 | 7 | 26.4 |
| 24 | 10 | 9 | 1 | 65 | 5 | 32.8 |

Figures 1 and 2 show the distribution of choices by the cost of each alternative (Figure 1) as well as the distribution of choices by the number of fewer restriction years[25] (Figure 2). Based on these figures, program cost seems to play a larger role in the decision to choose an alternative than the number of fewer restriction years that the alternative offers. The figures illustrate that the correlation between program cost and the percentage of time an alternative was chosen (when it was presented to respondents) was 0.4573. This is compared to a correlation of 0.0109 between the percentage of time an alternative was chosen and the number of fewer restriction years the alternative would provide.

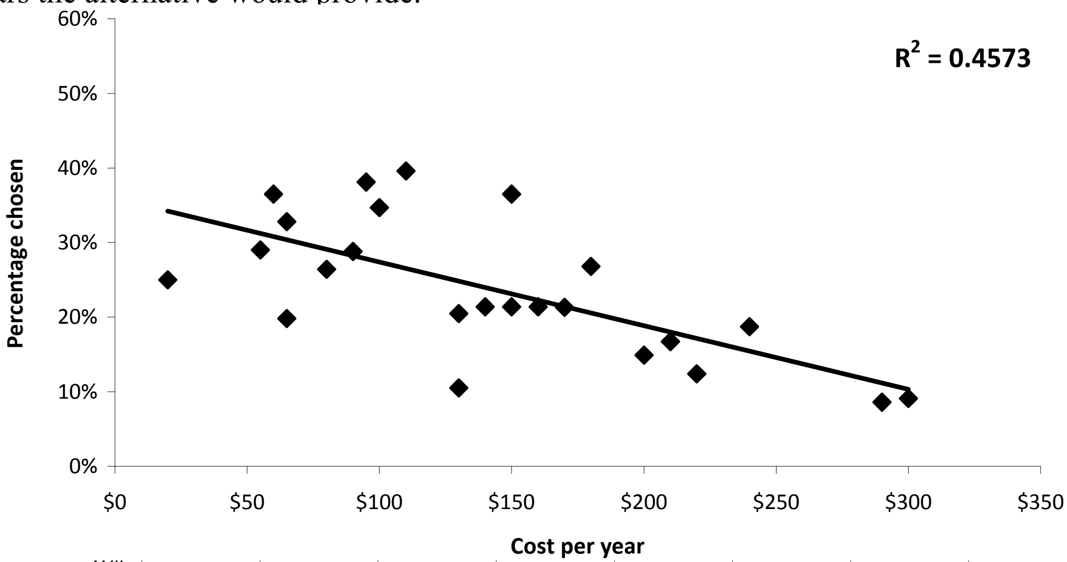



**Figure 1. Distribution of choices by program cost.**

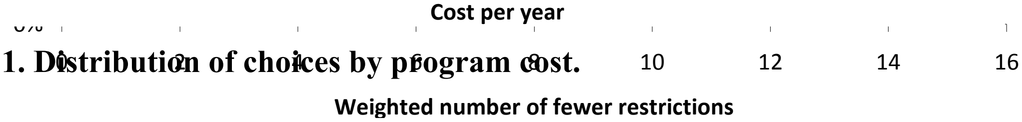



**Figure 2. Distribution of choices by number of (weighted) fewer restriction years.**

## G.2.4 Supply Option Preferences

Question 16 asked respondents to rank different options that water suppliers could undertake to improve future water supply reliability. There were 9 choices presented on the survey, including:

31. Finding new surface water supplies outside the Bay Area region (i.e., importing water from other parts of the state)
32. Increasing available supplies of water by transferring more water from agricultural uses in the state to urban areas such as the Bay Area

20. [25]. The number of fewer Level 2 restriction years was assigned a weight of 3 to represent the significance respondents placed on reducing Level 2 restrictions compared to Level 1 restrictions, which are much less severe.

33. Investing in regional desalination facilities, to convert ocean, bay, or brackish waters into part of the local drinking water supply in some regions.
34. Increasing the price of water to residential, commercial, and industrial users so they will use less
35. Requiring low-water-use landscaping (e.g., Xeriscape) in new homes and redevelopment projects
36. Increasing available supplies of water by expanding or adding new storage reservoirs so more water can be stored from wet years
37. Expanding the use of recycled water for outdoor irrigation and industrial uses
38. Using highly purified recycled water to replenish groundwater supplies in parts of the state, thereby enabling greater use of local well water in those areas
39. Promoting voluntary water conservation through education and incentives (e.g., rebates for homes that switch to low water using appliances or landscaping).

Respondents were asked to rank their top five most-preferred options. Figure 3 shows the percentage of respondents who selected a given option as one of their top three most-preferred choices. Three responses stand out as the preferred choices: expanding the use of recycled water for outdoor irrigation and industrial purposes, promoting more voluntary conservation through incentives and education; and requiring low-water-use landscaping in new and remodeled homes (e.g., Xeriscapes). Increasing available supplies of water by expanding or adding new storage reservoirs so more water can be stored in wet years was also a relatively popular option.

Question 16A of the survey asked respondents to choose their least preferred option of the remaining unranked choices. Figure 4 reveals close to 25% of respondents chose "finding new surface water supplies from outside the Bay Area region" as their least preferred option. About 23% of respondents chose "increasing the price of water to residential, commercial, and industrial users so that they will use less" as the option they prefer the least.

In addition to the supply option preferences reflected above, we also asked specific questions about preferences for different versions of similar program options. For example, we asked respondents to indicate which of two water storage options they preferred, and which of two water reuse options they preferred. Responses are summarized in Tables 12–15.

Finally, to further explore how SFPUC customers feel about specific options, respondents were asked whether they agreed with a series of statements related to potential water management strategies. As shown in Table 16, support for the expanded use of recycled water within the city seems to be fairly high (with 84.4% of respondents agreeing or strongly agreeing that SFPUC should consider expanding the amount of recycled water used in the city). The majority of respondents (74.3%) also agree or strongly agree that SFPUC should actively expand the amount of water conservation in the city. Both of these observations are consistent with findings from

Question 16 of the survey (see Figures 3–4). A number of respondents (57.9%) feel that SFPUC should raise rates for households or businesses that use more than their fair share of water. Fewer respondents (45.5%) agree or strongly agree that SFPUC should consider desal as an alternative source of water supply.

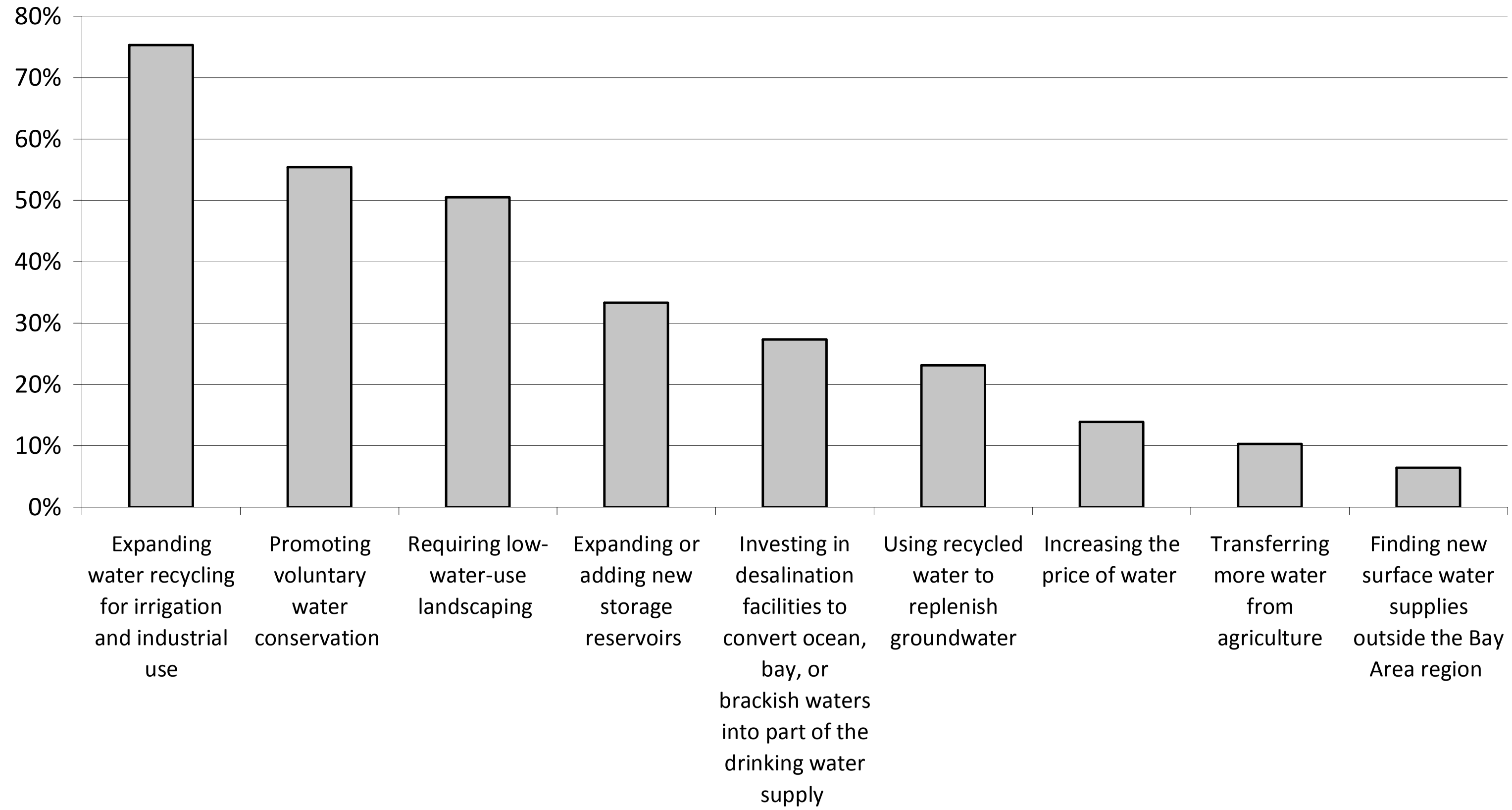



**Figure 3. Percentage of respondents who selected a given option as one of their top three choices for dealing with future water shortages**.

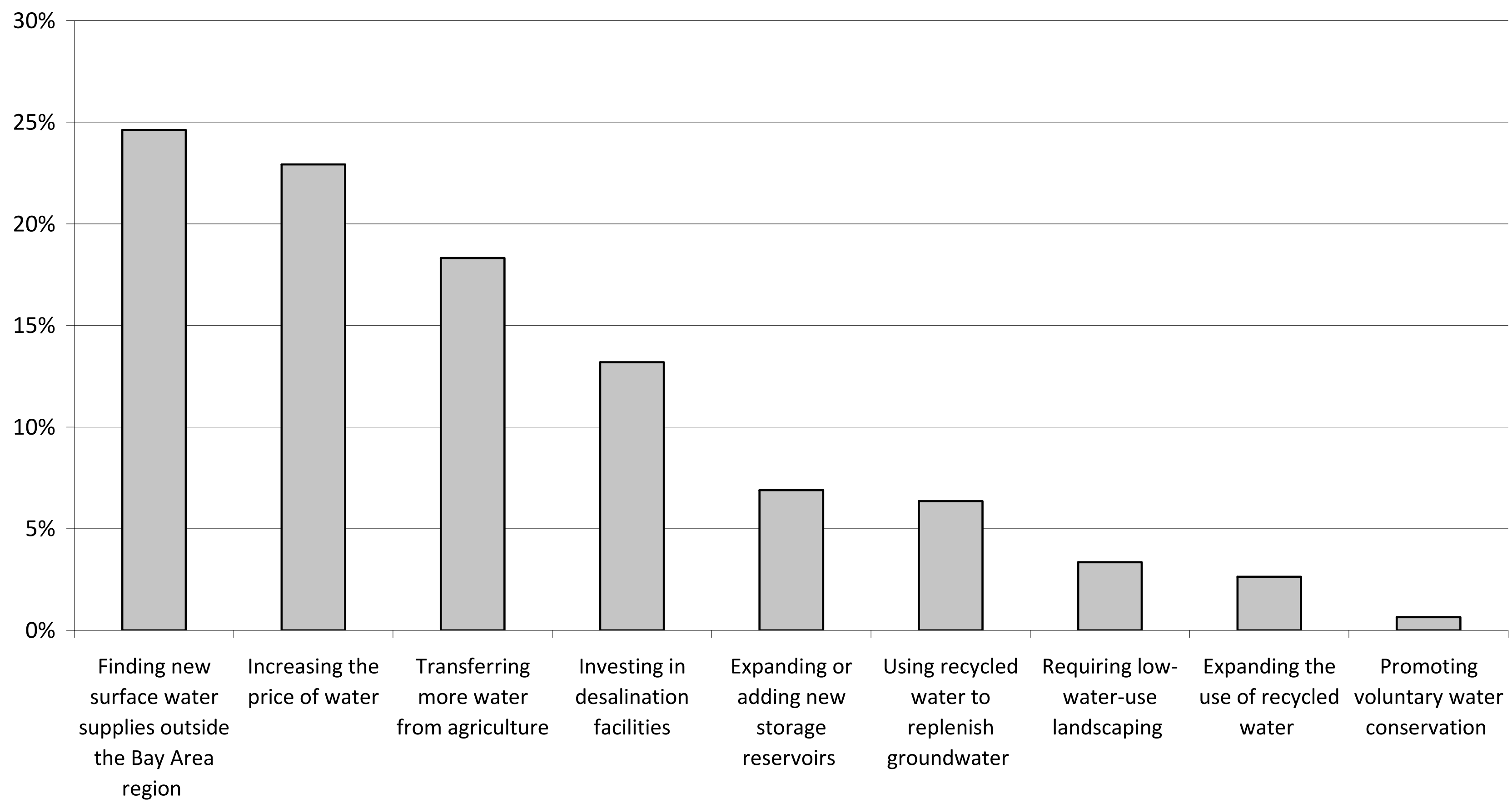



**Figure 4. Percentage of respondent who selected a given option as their *least* preferred option for dealing with future water shortages.**

**Table 12. Q17: Of the two water storage options below, which do you prefer?**

| | |
|---|---|
| Refused | 1.2% |
| Increasing water storage capacity by expanding or building new reservoirs in the Bay Area | 71.8% |
| Increasing water storage capacity by expanding existing reservoirs or building new reservoirs in other areas of the state (and importing the water to the Bay Area) | 27.0% |

**Table 13. Q18: Of the two water transfer and import options below, which do you prefer?**

| | |
|---|---|
| Refused | 1.2% |
| Increasing water imports from outside of the Bay Area region | 54.0% |
| Increasing water transfers from agriculture | 44.8% |

**Table 14. Q19: Of the two water conservation options below, which do you prefer?**

| | |
|---|---|
| Refused | 0.9% |
| Requiring low-water-use landscaping in new homes and existing homes that remodel more than 1,000 square feet | 61.8% |
| Promoting voluntary water conservation through education and incentives | 37.3% |

**Table 15. Q20: Of the two water recycling options below, which do you prefer?[a]**

| | |
|---|---|
| Refused | 0.9% |
| Expanding water recycling for outdoor irrigation and industrial uses | 57.0% |
| Expanding water recycling to replenish local groundwater supplies in parts of the state | 42.0% |

a. Note that because new piping is necessary for outdoor irrigation and industrial uses, expanding water recycling for outdoor irrigation and industrial uses costs three times as much as expanding water recycling to replenish reservoir supplies.

**Table 16. Agreement with proposed water management strategies**

| | Refused (%) | Strongly disagree (%) | Disagree (%) | Neutral (%) | Agree (%) | Strongly agree (%) |
|---|---|---|---|---|---|---|
| SFPUC should actively expand the amount of water conservation in the City | 0.9 | 1.6 | 2.5 | 20.7 | 43.7 | 30.6 |
| SFPUC should consider expanding the amount of recycled water used in the City | 0.9 | 1.2 | 0.9 | 12.6 | 44.5 | 39.9 |
| SFPUC should seriously consider desalination to provide more water to the City | 1.0 | 4.2 | 11.6 | 37.7 | 28.1 | 17.4 |
| SFPUC should raise rates for households and businesses that use more than their fair share of water | 0.9 | 7.3 | 7.0 | 26.8 | 32.1 | 25.8 |

## G.2.5 Conditional Logit Model for Estimating WTP

Economists use a variety of models to analyze the type of data collected in the choice questions used in this survey. A well-accepted and straightforward model often applied is the conditional logit model. This model is used to estimate the probabilistic effect of a choice attribute or personal characteristic on the outcome of a given choice.

Since a respondent's choice is contingent on observed and random respondent characteristics, our model includes several variables to account for the variation in observed characteristics of a choice. We include the cost of the alternative associated with a given choice. We also define two attributes as the number of fewer restriction years relative to the status quo for each restriction level. Finally, we include personal characteristics, including education, age, income, a dummy variable indicating whether the respondent believes increasing water supplies is of high or low importance, the amount of time living in San Francisco, a dummy variable indicating yard ownership status, and a dummy variable indicating whether a respondent pays his or her own water bill. The personal characteristics are interacted with a dummy variable indicating whether the choice decision concerns an alternative to the status quo. This provides variability to the data and allows the model to estimate the impact of personal characteristics on choosing an alternative to the status quo.

Table 17 displays the results from the conditional logit model. The model uses 3,561 observations, an expansion of the 417 observations by nine choices (three choice questions and three choices per question), less 192 observations due to questions that were left unanswered by respondents.

**Table 17. Conditional logit model for selecting an option as an alternative to the status quo (*n* = 3,753; log likelihood = -1,141.382)**

| Choice | Coefficient | Robust standard error | z | P > \|z\| | [95% confidence interval] | |
|---|---|---|---|---|---|---|
| Cost per year | -0.011 | 0.001 | -7.59 | 0.000 | -0.013 | -0.008 |
| Reduction in level 1 restrictions | 0.129 | 0.042 | 3.10 | 0.002 | 0.047 | 0.211 |
| Reduction in level 2 restrictions | 0.391 | 0.067 | 5.86 | 0.000 | 0.260 | 0.522 |
| Chose alternative × education | 0.320 | 0.114 | 2.81 | 0.005 | 0.096 | 0.543 |
| Chose alternative × age | 0.0340 | 0.079 | 0.43 | 0.668 | -0.121 | 0.189 |
| Chose alternative × income | -0.020 | 0.052 | -0.38 | 0.703 | -0.121 | 0.081 |
| Chose alternative × increasing water supplies important | 0.066 | 0.143 | 0.46 | 0.642 | -0.214 | 0.347 |
| Chose alternative × time living in San Francisco | -0.303 | 0.099 | -3.07 | 0.002 | -0.497 | -0.110 |
| Chose alternative × own yard | -0.341 | 0.181 | -1.89 | 0.059 | -0.695 | 0.013 |
| Chose alternative × pay water bill | -0.118 | 0.177 | -0.67 | 0.505 | -0.465 | 0.229 |

As expected, cost has a negative impact on the likelihood of choosing a given option (i.e., as cost increases, the likelihood of choosing an alternative decreases). The amount of time an individual has lived in San Francisco is also found to have a negative impact on the likelihood of choosing a given option. The level of education an individual seems to have a positive impact on the likelihood of choosing an alternative option (i.e., as level of education increases, the likelihood of choosing an alternative increases). Finally, respondents that have their own yard are less likely to choose an alternative option. The other variables are not statistically significant from zero in the model estimated.

Note that the empirical conclusion above assumes a constant (i.e., linear) WTP for reductions in restriction years. Additional statistical analyses have been conducted to explore potential non-linear effects of changes in restriction years on WTP (i.e., to explore whether the anticipated reduction in marginal WTP is observed as the number of avoided restrictions declines).

Our more complex empirical analyses were aimed to better examine how the WTP estimates may be influenced by the total number of years of restrictions avoided (rather than assuming each year is valued equally, regardless of how many years in total have use restrictions eliminated). The results of our empirical evaluation (shown below) revealed no statistically significant difference between the linear results reported above and the non-linear variations we estimated.

## G.2.6 WTP Measures

Using the parameter estimates from the conditional logit model in Section 5, we calculated WTP measures for reducing Level 1 and Level 2 restrictions. Table 18 presents the estimated mean WTP for a one-summer reduction in each restriction separately. As shown, the WTP estimates for reducing Level 1 and 2 restrictions are statistically significant than zero. These results imply a positive WTP by respondents for increasing water reliability to avoid both levels of restrictions.

**Table 18. WTP estimates (*n* = 3,753)**

| Choice | Coefficient | Robust standard error | z | P > \|z\| | [95% confidence interval] | |
|---|---|---|---|---|---|---|
| WTP to reduce Level 1 restrictions by 1 summer out of the next 20 | 12.25 | 3.28 | 3.74 | 0.00 | 5.83 | 18.67 |
| WTP to reduce Level 2 restrictions by 1 summer out of the next 20 | 37.16 | 4.63 | 8.03 | 0.00 | 28.09 | 46.22 |
| WTP to avoid all restrictions | 233.98 | 34.53 | 6.78 | 0.00 | 166.29 | 301.65 |

To interpret these results in the context of understanding the mean household WTP for specific water supply enhancement programs, one needs to add the mean values based on the number and type of restrictions the program is expected to eliminate. For example, in the survey, the next 20 years were portrayed as yielding an anticipated eight summers with Level 1 restrictions, eight summers with Level 2 restrictions, and four summers with Level 3 restrictions. Suppose an ambitious supply enhancement program was expected to eliminate imposition of all of the projected Level 1 and Level 2 use restrictions. The mean annual WTP results above suggest that the total household WTP for this program would be ($12.25 × 10) + ($37.16 × 3) = $233.98 per year. This conclusion assumes a constant WTP for reductions in restriction years.

To gauge the strength of this assumption, we estimated several models with nonlinear specifications. Using the best-fit nonlinear model, the mean WTP for a program that eliminates the imposition of all projected Level 1 and Level 2 use restrictions = $202.16. This estimate is not statistically different from the estimate using the linear model. More generally, we find that the linear model underestimates WTP for smaller changes in summers with restrictions relative to the non-linear models, and overestimates WTP for larger changes in summers with restrictions. However, in the range of reductions presented in the survey scenarios, the linear model provides a reliable average approximation of WTP for these scenarios.

*Appendix H*

# Data Analysis of a Willingness to Pay Stated Choice Survey of Water Supply Reliability in the Utility X Service Area

## H.1 Introduction

Knowledge Networks (KN) administered the Utility X Survey to 418 panelists in the City X metro area in the first half of June, 2010. KN administered the survey to 418 people, drawn from the KnowledgeNetwork™ Internet Panel, as supplemented using another Internet panel accessed by KN. All panelists who completed the survey live in the area served by Utility X. To ensure this, we provided KN with a list of zip codes that were completely contained within the Utility X service area (including water served by wholesale utility customers to their residential accounts).

Respondents were presented with three sets of choice questions near the end of the survey in order to evaluate their preferences for a range of possible programs to reduce (to varying degrees) different levels of water use restrictions over the next 20 years. Each choice set allowed respondents to choose the program called "No Additional Actions," which we refer to in this report as the status quo. The experimental design for this study comprised 24 different programs with varying levels of use restrictions. For each choice set, KN randomly selected two of these programs. Once a program was selected in any of the choice questions for a given participant, it was not selected again in future choice questions (i.e., no replacement of programs). This allowed us to get three choice set data observations for each respondent.

The results presented in the following sections relied on 418 observations from City X. Weights were generated by KN to adjust for sample design, non-coverage, and non-response biases. These weights were used in the analysis in order to generalize results to residents of specific City X zip codes who participated in the study.

Section 2 first presents how select respondent characteristics affected the likelihood of a respondent choosing an alternative to the status quo. This includes a summary of education, age, gender, income, ownership status of living quarters, work status, opinion on increasing water supplies, ownership status of yard, and payment of water bill. Section 3 presents the distribution of choices by version alternative. Sections 4, 5, and 6 provide more detailed empirical analysis of the data, including willingness to pay (WTP) estimates and respondent preferences for specific water supply options.

## H.2 Characteristics Predicting Choice Behavior

This section presents how select respondent characteristics affected the likelihood of choosing an alternative to the status quo. Since each respondent was asked three choice questions, there are multiple ways to define a binary choice variable that indicates a respondent's choice for the status quo or an alternative. The most stringent definition – the one used for this analysis – requires a respondent to have chosen an alternative to the status quo in all three choice questions for this choice variable to take on a value of 1, and 0 otherwise. The following cross tabs demonstrate how various respondent characteristics affected the outcome of this choice variable.

### H.2.1 Education

Table 1 demonstrates a positive relationship between education level and the likelihood of choosing alternatives to the status quo in all three choice questions.

**Table 1. Education (*n* = 415)**

| Choice | Less than high school (%) | High school (%) | Some college (%) | Bachelors (%) |
|---|---|---|---|---|
| Status quo | 100.0 | 70.8 | 66.2 | 57.7 |
| Alternative | 0.0 | 29.2 | 33.8 | 42.3 |

### H.2.2 Age

Table 2 suggests there is no clear relationship between age and the likelihood of choosing alternatives to the status quo across choice questions.

**Table 2. Age (*n* = 415)**

| Choice | 18–29 (%) | 30–44 (%) | 45–59 (%) | 60 + (%) |
|---|---|---|---|---|
| Status quo | 64.9 | 57.4 | 63.6 | 74.1 |
| Alternative | 35.1 | 42.6 | 36.4 | 26.0 |

### H.2.3 Gender

Table 3 demonstrates only a slight difference in sample proportions across gender for those choosing alternatives to the status quo, with males being more likely to choose an alternative.

**Table 3. Gender (*n* = 415)**

| Choice | Male (%) | Female (%) |
|---|---|---|
| Status quo | 62.5 | 66.8 |
| Alternative | 37.5 | 33.2 |

### H.2.4 Income

Table 4 shows an increasing likelihood of choosing alternatives to the status quo in all three choice questions as income category increases.

**Table 4. Income (*n* = 410)**

| Choice | < $20,000 (%) | $20,000–$29,999 (%) | $30,000–$49,999 (%) | $50,000–$74,999 (%) | $75,000–$99,999 (%) | > $100,000 (%) |
|---|---|---|---|---|---|---|
| Status quo | 6. 69.5 | 70.0 | 70.7 | 60.0 | 67.7 | 49.6 |
| Alternative | 30.5 | 30.1 | 29.3 | 40.1 | 32.3 | 50.4 |

### H.2.5 Ownership status of living quarters

Table 5 reveals a clear difference between respondents who own or rent their living quarters with payment compared to those who occupy their living quarters without payment of cash rent. Respondents who do not pay for their living quarters have a far greater likelihood of choosing alternatives to the status quo.

**Table 5. Ownership status of living quarters (*n* = 415)**

| Choice | Owned or being bought by you or someone in your household (%) | Rented for cash (%) | Occupied without payment of cash rent (%) |
|---|---|---|---|
| Status quo | 66.2 | 66.2 | 14.8 |
| Alternative | 33.8 | 33.8 | 85.2 |

### H.2.6 Work status

Work status appears to affect a respondent's likelihood of choosing alternatives to the status quo in all three choice questions, as shown in Table 6. Respondents who work as paid employees have the greatest likelihood of choosing alternatives to the status quo, while those not working due to a temporary layoff have the lowest likelihood and chose the status quo almost universally.

**Table 6. Work status (*n* = 415)**

| Choice | Working – as a paid employee (%) | Working – self-employed (%) | Not working – on temporary layoff from job (%) | Not working – looking for work (%) | Not working – retired (%) | Not working – disabled (%) | Not working – other (%) |
|---|---|---|---|---|---|---|---|
| Status quo | 52.2 | 67.8 | 95.7 | 76.2 | 74.8 | 80.6 | 63.0 |
| Alternative | 47.8 | 32.2 | 4.3 | 23.8 | 25.2 | 19.4 | 37.0 |

### H.2.7 Opinion on increasing water supplies

Question 2 asked respondents how important "increasing water supplies" is as an issue in the state. Table 7 shows respondents who answered "very" or "extremely important" to Question 2 had a greater likelihood of choosing alternatives to the status quo in all three choice questions than those who consider the issue less important.

**Table 7. Opinion on increasing water supplies (*n* = 415)**

| Choice | Increasing water supplies low importance (%) | Increasing water supplies high importance (%) |
|---|---|---|
| Status quo | 70.1 | 61.2 |
| Alternative | 29.9 | 38.8 |

### H.2.8 Ownership status of yard

Table 8 suggests there is no clear relationship between yard ownership and the likelihood of choosing alternatives to the status quo across choice questions.

**Table 8. Ownership status of yard (*n* = 415)**

| Choice | Do not own yard | Own yard |
|---|---|---|
| Status quo | 64.5 | 65.2 |
| Alternative | 35.5 | 34.9 |

### H.2.9 Payment of water bill

Table 9 shows a higher sample proportion of respondents who pay their own water bill choosing alternatives to the status quo in all three choice questions compared to those who do not pay their own bill.

**Table 9. Payment of water bill (*n* = 415)**

| Choice | Does not pay own bill (%) | Pays own bill (%) |
|---|---|---|
| Status quo | 69.2 | 62.1 |
| Alternative | 30.8 | 38.0 |

## H.3 Distribution of Choices by Version Alternative

Table 10 and Figures 1 and 2 summarize the distribution of choices across the status quo, alternatives, and refusals. In Table 1, the column titled "Percentage chosen" displays the percentage of respondents who chose each version out of the respondents who were presented that version. For example, of the respondents who were presented Version 1, 24% chose Version 1 over the status quo and the other version presented. There are 1,254 observations underlying Table 10, as each of the 418 respondents were asked three choice questions. Although this analysis does not address the variation of alternative versions presented to respondents, Table 11 and Figures 1 and 2 provide feedback about respondent responses to each alternative version. About half of the responses were refusals or choices for the status quo (50.3%). The remaining responses were allocated across alternatives to the status quo, with more responses allocated to alternatives with lower costs.

Figures 1 and 2 show the distribution of choices by the cost of each alternative (Figure 1) as well as the distribution of choices by the number of fewer restriction years[26] (Figure 2). Based on these figures, program cost seems to play a larger role in the decision to choose an alternative than the number of fewer restriction years that the alternative offers. The figures illustrate that the correlation between program cost and the percentage of time an alternative was chosen (when it was presented to respondents) was 0.73. This is compared to a correlation of 0.23 between the percentage of time an alternative was chosen and the number of fewer restriction years the alternative would provide.

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21. [26]. The number of fewer Level 2 restriction years was assigned a weight of 3 to represent the significance respondents placed on reducing Level 2 restrictions compared to Level 1 restrictions, which are much less severe.

**Table 10. Distribution of choices by version alternative ($n$ = 1,254)**

| Version | Summers with no restrictions | Summers with Level 1 restrictions | Summers with Level 2 restrictions | Cost per year | Cost per month | Percentage chosen |
|---|---|---|---|---|---|---|
| Refused | | | | | | 2.0 |
| Status quo | 7 | 10 | 3 | 12 | 1 | 48.3 |
| 1 | 11 | 8 | 1 | 160 | 13 | 24.0 |
| 2 | 12 | 6 | 2 | 95 | 8 | 47.0 |
| 3 | 13 | 5 | 2 | 210 | 18 | 12.8 |
| 4 | 15 | 5 | 0 | 300 | 25 | 11.0 |
| 5 | 10 | 8 | 2 | 60 | 5 | 36.4 |
| 6 | 11 | 6 | 3 | 130 | 11 | 20.2 |
| 7 | 13 | 7 | 0 | 240 | 20 | 17.1 |
| 8 | 15 | 4 | 1 | 290 | 24 | 9.3 |
| 9 | 12 | 5 | 3 | 90 | 8 | 33.0 |
| 10 | 12 | 8 | 0 | 110 | 9 | 38.9 |
| 11 | 9 | 8 | 3 | 65 | 5 | 39.0 |
| 12 | 14 | 6 | 0 | 150 | 13 | 25.9 |
| 13 | 13 | 6 | 1 | 220 | 18 | 11.4 |
| 14 | 11 | 7 | 2 | 150 | 13 | 18.2 |
| 15 | 8 | 9 | 3 | 20 | 2 | 39.3 |
| 16 | 10 | 7 | 3 | 55 | 5 | 30.6 |
| 17 | 14 | 4 | 2 | 130 | 11 | 27.7 |
| 18 | 14 | 5 | 1 | 140 | 12 | 28.6 |
| 19 | 13 | 4 | 3 | 200 | 17 | 7.7 |
| 20 | 12 | 7 | 1 | 100 | 8 | 33.1 |
| 21 | 11 | 9 | 0 | 170 | 14 | 14.7 |
| 22 | 16 | 4 | 0 | 180 | 15 | 16.7 |
| 23 | 9 | 9 | 2 | 80 | 7 | 31.9 |
| 24 | 10 | 9 | 1 | 65 | 5 | 32.0 |

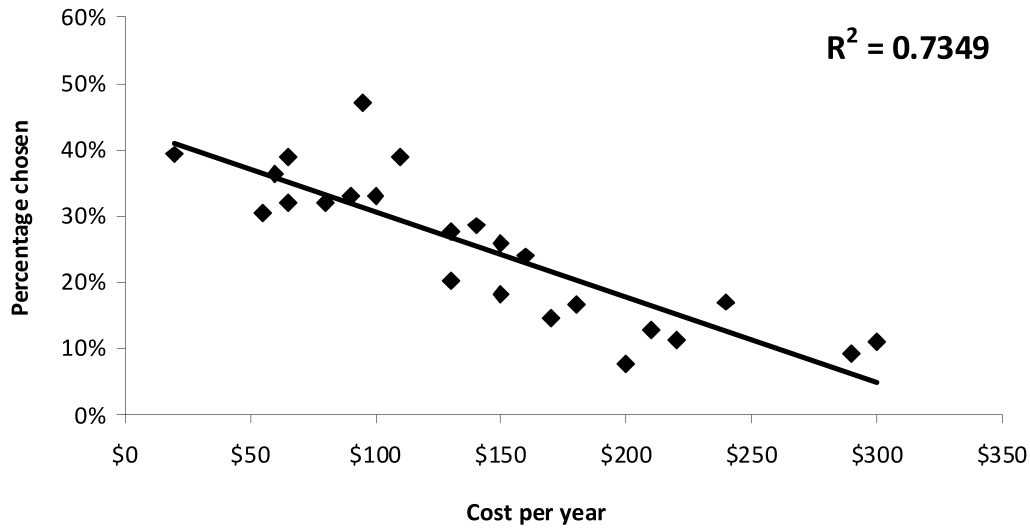


**Figure 1. Distribution of choices by program cost.**

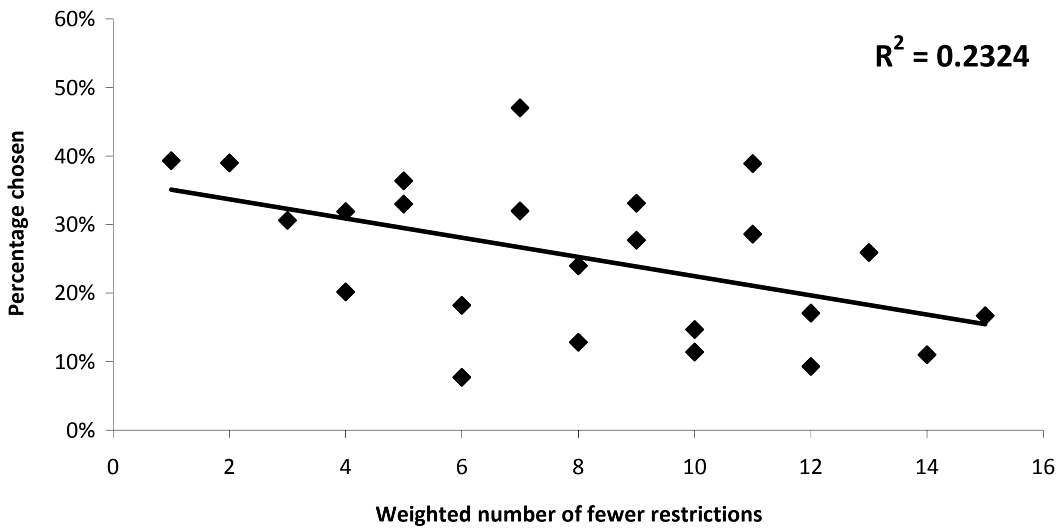


**Figure 2. Distribution of choices by number of fewer restriction years.**

## H.4 Conditional Logit Model for Estimating WTP

Economists use a variety of models to analyze the type of data collected in the choice questions used in this survey. A well-accepted and straightforward model often applied is the conditional logit model. This model is used to estimate the probabilistic effect of a choice attribute or personal characteristic on the outcome of a given choice.

Since a respondent's choice is contingent on observed and random respondent characteristics, our model includes several variables to account for the variation in observed characteristics of a choice. We include the cost of the alternative associated with a given choice. We also define two attributes as the number of fewer restriction years relative to the status quo for each restriction level. Finally, we include personal characteristics, including education, age, income, a dummy variable indicating whether the respondent believes increasing water supplies is of high or low importance, the amount of time living in City X, a dummy variable indicating yard ownership status, and a dummy variable indicating whether a respondent pays his or her own water bill. The personal characteristics are interacted with a dummy variable indicating whether the choice decision concerns an alternative to the status quo. This provides variability to the data and allows the model to estimate the impact of personal characteristics on choosing an alternative to the status quo.

Table 11 displays the results from the conditional logit model. The model uses 3,678 observations, an expansion of the 418 observations by nine choices (three choice questions and three choices per question), less 84 choices that were left unanswered by respondents.

**Table 11. Conditional logit model for selecting an option as an alternative to the status quo (*n* = 3,678; log likelihood = -1,189.99)**

| Choice | Coefficient | Robust standard error | z | P > \|z\| | [95% confidence interval] | |
|---|---|---|---|---|---|---|
| Cost per year | -0.010 | 0.002 | -6.71 | 0.00 | -0.014 | -0.007 |
| Reduction in Level 1 restrictions | 0.072 | 0.045 | 1.61 | 0.11 | -0.016 | 0.160 |
| Reduction in Level 2 restrictions | 0.216 | 0.073 | 2.95 | 0.00 | 0.072 | 0.359 |
| Chose alternative education | 0.118 | 0.085 | 1.40 | 0.16 | -0.048 | 0.285 |
| Chose alternative × age | -0.174 | 0.089 | -1.95 | 0.05 | -0.349 | 0.001 |
| Chose alternative × income | 0.109 | 0.056 | 1.99 | 0.05 | -0.002 | 0.216 |
| Chose alternative × increasing water supplies important | 0.231 | 0.157 | 1.47 | 0.14 | -0.077 | 0.540 |
| Chose alternative × time living in City X | -0.077 | 0.068 | -1.13 | 0.26 | -0.210 | 0.056 |
| Chose alternative × own yard | -0.184 | 0.232 | -0.79 | 0.43 | -0.639 | 0.271 |
| Chose alternative × pay water bill | 0.139 | 0.224 | 0.62 | 0.54 | -0.300 | 0.577 |

As expected, cost has a negative impact on the likelihood of choosing a given option, while reducing Level 2 restrictions and higher education have a positive impact. Age is also found to have a negative impact on the likelihood of choosing a given option. The other variables are not statistically significant from zero in the model estimated. Additional models will be run that explore other functional forms (e.g., non-linear models) that allow for greater flexibility in the parameter estimates (e.g., random parameters logit).

## H.5 WTP Measures

Using the parameter estimates from the conditional logit model in Section 5, we calculated WTP measures for reducing Level 1 and Level 2 restrictions. Table 12 presents the estimated mean WTP for a one-summer reduction in each restriction separately. Both WTP estimates are statistically significant from zero. The mean WTP for reducing Level 1 restrictions by 1 year out of the next 20 is $6.89, while the corresponding WTP measure for reducing Level 2 restrictions by 1 year out of the next 20 is $20.55. These results imply a positive WTP by respondents for increasing water reliability and thereby reducing summer restrictions with a higher WTP to avoid the more severe restriction level.

**Table 12. WTP estimates (*n* = 3,678)**

| Choice | Coefficient | Robust standard error | z | P > \|z\| | [95% confidence interval] | |
|---|---|---|---|---|---|---|
| WTP to reduce Level 1 restrictions by one summer out of the next 20 | $6.89 | $3.71 | 1.85 | 0.06 | -$0.40 | $14.16 |
| WTP to reduce Level 2 restrictions by one summer out of the next 20 | $20.55 | $5.40 | 3.81 | 0.00 | $9.97 | $31.13 |
| WTP to avoid all restrictions | $130.49 | $41.09 | 3.18 | 0.01 | $49.96 | $211.02 |

To interpret these results in the context of understanding the mean household WTP for specific water supply enhancement programs, one needs to add the mean values based on the number and type of restrictions the program is expected to eliminate. For example, in the survey, the next 20 years were portrayed as yielding an anticipated eight summers with Level 1 restrictions, eight summers with Level 2 restrictions, and four summers with Level 3 restrictions. Suppose an ambitious supply enhancement program was expected to eliminate imposition of all of the projected Level 1 and Level 2 use restrictions. The mean annual WTP results above suggest that the total household WTP for this program would be (6.89 × 10) + ($20.55 × 3) = $130.49 per year (does not add due to rounding). This conclusion assumes a constant WTP for reductions in restriction years.

To gauge the strength of this assumption of constant (i.e., linear) WTP across the number of water use restrictions avoided, we estimated several models with non-linear specifications. Using the best-fit non-linear model, the mean WTP for a program that eliminates the imposition of all projected Level 1 and Level 2 use restrictions = $109.51. This estimate is not statistically different from the estimate shown in the previous paragraph as derived from the linear model. More generally, we find that the linear model underestimates WTP for smaller changes in the number of summers with restrictions relative to the nonlinear models, and overestimates WTP for larger changes in the number of future summers with restrictions. However, in the range of reductions presented in the survey scenarios – 1 to 6 summer reductions for level 1 restrictions, and 0 to 3 summer reductions for level 2 restrictions – the linear model provides a reliable average approximation of WTP for these scenarios.

## *Advancing the Science of Water Reuse and Desalination*




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