SANTA CRUZ WATER DEPARTMENT

WATER CURTAILMENT STUDY

Final Report

Prepared by:

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Water Resource Planning and Management

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- Lenne Bennett
- Bill Cox
- Bill Malone
- Karsten Mueller
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EXECUTIVE SUMMARY

This study has been prepared to provide the City of Santa Cruz with information on the manner in which potential future peak-season water shortages would affect different classes of water consumers in the Santa Cruz Water Department's (SCWD) service area. The intent of this study is not to quantify these impacts, but rather to describe the actions that different customer classes are likely to take to reduce water consumption by specified amounts and the economic and non-economic hardships that these actions would impose on customers.

BACKGROUND AND PURPOSE

The City of Santa Cruz must make a number of critical water supply decisions. The City's water system is highly vulnerable to shortage in drought years when the San Lorenzo River and coastal sources run low. The water system is capable of meeting current demands in normal and wet years. In critically dry or extended dry periods, through, there is insufficient water available from the City's various supply sources to satisfy the community's needs. The storage capacity of Loch Lomond Reservoir is limited and insufficient to carry the system for extended periods of time. This deficiency is expected to worsen over time.

In two previous droughts (1976-77 and 1987-92), the City faced maximum peak-season shortages approaching 30%. In comparable future hydrological events, with increasing demands, shortages will be more severe. Shortages are also expected to become more frequent. By the year 2020, the City could experience supply shortfalls in three out of four years; shortages would occur even under average rainfall and runoff conditions.

In its planning to address these issues, the City has already determined that it is willing to accept some degree of use curtailment to manage future water shortages. Indeed, in its Integrated Water Planning (IWP) process, the Santa Cruz Water Department (SCWD) is attempting to evaluate three potential complementary approaches to addressing the City's current and future water supply needs:

- Enhanced water conservation efforts;
- Periodic demand curtailment due to water shortage; and
- Additional water supplies.

The IWP must determine the combination of these approaches that best meets the needs of the citizenry. A decision by the City to permit larger and more future curtailments would mean that future supply and/or conservation projects could be deferred or downsized.

Thus, this study is one of three efforts that have been or are being undertaken as IWP "building blocks." The results described in the following pages will be combined with the results of the Water Conservation Plan and the Water Supply Study to develop the IWP. The study examines six different levels of shortage severity, ranging from a mild (10%) to an extreme (60%) system-

wide peak-season shortage.[1] For each of these, the study looks at likely actions that customers in each customer class would take and the hardships that these actions would impose. The intent is to enable comparisons across shortage levels and between the impacts of different shortage severities and possible investments in new supplies and/or conservation programs.

WATER USAGE PRIORITIES

This report assumes that shortages will be allocated to classes of service based on the classification of end uses into three priorities, which are consistent with those in the City's current water shortage contingency plan, codified in Ordinance 92-10:

1. **Health and safety**. This is the highest priority use. All residential interior and non-residential sanitary uses are assumed to fall under this priority, as is all usage at the wastewater treatment plant.

2. **Business**. This second priority use includes all usage that is related to commercial activity in the city. All non-sanitary uses in the business class are assigned this priority, as are all usage by the agriculture, industrial, golf, municipal, and miscellaneous classes of service.

3. **Outdoor irrigation**. This lowest priority use includes all outdoor usage in the single family, multi-family, UCSC, and large landscape classes.

Under this priority scheme, end uses related to health and safety are assumed to be cut back the least in a water shortage, while irrigation will be cut back the most. The prioritization recognizes the critical importance to the city's economic well-being and the well-being of its citizens of business activities. While these uses are of a lower priority than health and safety uses, the ranking attempts to shield them from the full brunt of a water shortage. It should also be noted that such outdoor uses as golf course irrigation, agricultural irrigation, and commercial irrigation are all considered to have a business priority.

Table ES-1 shows the manner in which current peak-season class demands are divided among the three usage priorities.[2] Nearly half of total demands are for "health and safety," with approximately one-fourth each for business and irrigation.

[1] The peak season is defined as the months of April through October.

[2] The demand figures in Table 1 and throughout this section are based on the 1998 Water Demand Investigation developed by Maddaus Water Management.

Table ES-1

CUSTOMER CLASS YEAR 2000 PEAK-SEASON DEMANDS BY USAGE PRIORITY

(MILLIONS OF GALLONS)

CUSTOMER CLASS	USAGE PRIORITY			TOTAL
	HEALTH AND SAFETY	BUSINESS	IRRIGATION	
Single Family	661	--	382	1,043 (37%)
Multi-Family	428	--	173	601 (21%)
Business (incl. Agriculture)	163	415	--	578 (20%)
University of California	97	--	41	138 (5%)
Large Landscape	--	--	135	135 (5%)
Golf Irrigation	--	117	--	117 (4%)
Industrial	--	155	--	155 (5%)
Municipal	--	41	--	41 (1%)
Waste Water Plant	13	--	--	13 *
Miscellaneous	--	8	--	8 *
TOTAL	1,362 (48%)	736 (26%)	732 (26%)	2,830 (100%)

** Less than 0.5% of total.*

Estimates were then made of the degree to which each usage priority will be cut back during hypothetical system-wide peak-season shortages ranging from mild (10%) to extreme (60%). These cutbacks are shown in Table ES-2. At each level of system-wide shortage, the usage priorities are maintained, with health and safety uses experiencing the smallest shortage, followed by business uses, and irrigation uses. Note that, in order to partially shield health and safety and business uses from the full shortage impact, irrigation uses are cut back substantially. However, due to the relatively small (26%) fraction of total use that is in this lowest priority, the ability to do that is limited.

Finally, based on the Table ES-1 usage-priority composition of each customer class, the usage-priority cutbacks are transformed into class cutbacks. The results are shown in Table ES-3.[3] Table ES-3 also shows the volume shortfalls associated with each shortage condition.

Generally speaking, the overall cutbacks experienced by residential customers are close to the system-wide shortages, as are those for the University of California. Business and industrial customers, on the other hand, are cut back significantly less, while large landscape customers are cut substantially more. As a pure health and safety use, the wastewater plant reductions are smaller than those for any other class.

Table ES-2
ESTIMATED PEAK-SEASON USAGE-PRIORITY SHORTAGES

SHORTAGE CONDITION	PEAK-SEASON SYSTEM SHORTAGE	SHORTAGES BY USAGE PRIORITY		
		HEALTH AND SAFETY	BUSINESS	IRRIGATION
Mild	10%	0%	5%	30%
Moderate	20%	6%	15%	50%
Serious	30%	14%	25%	60%
Severe	40%	21%	30%	75%
Critical	50%	28%	35%	100%
Extreme	60%	42%	50%	100%

APPROACHES TO DATA COLLECTION

Different approaches were used to gather the necessary information from each customer class. For single family and multi-family residential shortage actions and hardships, the study relied on evidence from past California droughts, focus groups with Santa Cruz residential customers, and a study of shortage impacts on Santa Cruz residential landscapes. For business and industrial customers, the literature provided little guidance. The key instruments relied upon included a mail survey and a set of interviews with key representatives of each business sector. Shortage impacts on large landscape and golf course irrigation customers, the University of California, and municipal government agencies are based on single meetings held with representatives of each of those classes.

[3] Tables showing additional detail of the class shortage allocation are shown in Appendix B.

Table ES-3
ESTIMATED PEAK-SEASON CUSTOMER CLASS SHORTAGES
(BASE USE IN PEAK SEASON: 2,830 MILLION GALLONS)

SHORTAGE CONDITION	PEAK-SEASON SYSTEM SHORTAGE	VOLUME UNSERVED (MG)	SHORTAGES BY CUSTOMER CLASS						
			SINGLE FAMILY	MULTI-FAMILY	BUSINESS	U.C.	LARGE INDSCP.	INDUSTRIAL, GOLF, & MUNICIPAL	WASTE WATER PLANT
Mild	10%	280	11%	9%	4%	9%	30%	5%	0%
Moderate	20%	560	22%	19%	13%	20%	50%	15%	6%
Serious	30%	840	31%	27%	22%	28%	60%	25%	14%
Severe	40%	1120	41%	37%	27%	37%	75%	30%	21%
Critical	50%	1400	54%	48%	33%	49%	100%	35%	28%
Extreme	60%	1680	63%	56%	48%	60%	100%	50%	42%

SHORTAGE IMPACTS

The body of the report discusses a wide variety of shortage impacts for each class of SCWD customers. Following are brief summaries of the impacts on each class:

Residential Shortage Impacts

In general, it is likely that Santa Cruz residential customers could deal with system shortages in the 10%-20% range with little difficulty. At about the 30% level, as rationing becomes necessary, impacts become more significant. Chief among these is the anxiety accompanying rationing and its associated administrative and economic impacts. Effects on households of a 40% system shortage would be serious, with important lifestyle changes.

Catastrophic shortages in the 50%-60% range would raise customer concern about everyday water use to an unparalleled level. They would also impose major and burdensome lifestyle changes, some of which could well affect basic health and safety. There would be a greatly-increased level of conflict between customers and the City government to resolve issues and complaints. There may also be increased levels of conflict among neighbors and even within families, as water becomes a very scarce resource.

Business and Industrial Shortage Impacts

Business and industrial customers were asked about impacts of 15%, 25%, and 35% shortages, corresponding to 20-25%, 30-40%, and 50% system-wide shortages respectively.

Economic impacts due to a 15% cutback of business and industrial supplies will vary, with many businesses expecting these impacts to be manageable. Most businesses could get by with few if any production or employment cutbacks. Revenue losses for most sectors are anticipated to be fairly small. A key exception is the large semiconductor manufacturer which, even at this level of shortage, reports large ($17.5 million) losses.

Another exception is the "green industry", which would be significantly affected due to residential curtailments associated with this level of system shortage. Restaurants also report more significant impacts at this level due largely to their prior conservation actions.

Non-economic hardships are generally small, with the possible exception of hospitals and medical offices, hotels and motels, and retail establishments.

A 25% cutback to business and industrial customers would result in a larger production cutbacks and revenue losses, averaging about 20% across all sectors. Particularly hard-hit sectors include restaurants and retailers. Residential cutbacks at this level of shortage will be very damaging to retail nurseries and landscape contractors. Smaller hotels and motels may feel severe economic stress. The large semiconductor manufacturer faces some possibility of plant closure. Employee layoffs will become more common. City, county, and state tax revenues will be affected.

Non-economic hardships are much more significant, with 60% being described as "considerable" or "extreme." The level of care of medical patients will be affected. Some smaller businesses will curtail their operations or close entirely, perhaps permanently. There will be some loss of employment. The use of community facilities, such as school athletic fields, will be curtailed. Some customers may have difficulty complying with state regulations that depend on water use. The appearance of landscaping around business establishments will be seriously affected.

A 35% business and industrial shortage would result in average revenue losses across all businesses that are expected to exceed 30%. For restaurants and retailers, these revenue losses approach catastrophic levels. Business closures will be more common, with the largest City employer anticipating closure at this level. Landscape contractors, particularly new and/or small businesses, will be hit very hard. More hotels and motels will shut down permanently. Losses to the community's tax base are likely to be more significant.

Fully 50% of non-economic hardships are characterized as "extreme." Business closures and layoffs will affect more members of the community, with young entry-level employees more likely to be affected. Hospitals will limit activity to emergency cases only. Outpatient care will be reduced or eliminated with serious impacts on community health and safety. School athletic fields will likely be closed to community users. The general appearance of the City's business districts will suffer as all outdoor watering around businesses ceases.

Large Landscape and Golf Course Shortage Impacts

The priority-based allocation causes large landscape customers to experience the largest cutbacks of any customer class. Golf courses, as business customers, are spared the worst of the cutbacks.

Because of the diversity of these customers, the hardships imposed by these cutbacks will vary considerably. Generally speaking, it is likely that customers for which the landscape is not an integral input to the product or service being offered, will not suffer unduly as a result of outdoor irrigation reductions.[4]

On the other hand, customers for which a well-watered site is the essence of their business, could suffer substantial economic or non-economic hardships. Because of the priority-based allocation scheme, these customers will experience these large losses even during relatively moderate system-wide shortages.

University of California Shortage Impacts

Generally speaking, all university functions believed their missions would be seriously affected by water shortage. Due in part to the perceived base efficiency of UC water use, some university sectors project serious impacts even with relatively small shortages. Other sectors believe they could withstand these small shortages without suffering undue damage.

The primary mission of the university, of course, is education. A large number of meeting participants felt that the university's educational objectives could be compromised by water shortages. The extent to which this will occur is a function of shortage size, duration, and frequency.

Municipal Government Shortage Impacts

The impacts of a water shortage on municipal services are anticipated to be diverse. The primary City departments and functions that would be affected by a water shortage include:

Public Works Department

- Landfill/resource recovery center
- Corporation yard
- Wastewater and stormwater collection
- Wastewater treatment

Parks and Recreation Department

- Municipal golf course
- Parks
- Other functions, including street washing, open-space fire prevention, and river levee landscaping

[4] This is not to say that such customers will not suffer from shortage-related cutbacks in their non-large-landscape accounts.

Water Department

- Administration
- Customer service
- Conservation
- Distribution

SUMMARY OF IMPACTS

The nature of these impacts and their diversity provide a rich source of information to the City as it makes its water resource decisions. At the same time, this variety provides an analytical and policymaking challenge. Table ES-4 represents an attempt to summarize and supplement the detailed class-specific shortage impact information presented in the report body. The table rates the overall shortage impacts for each class[5] on a 6-point scale, ranging from "little or through "catastrophic" impact.

These ratings are relative within each class and are necessarily somewhat subjective. They are intended to enable quick comparisons within each class of service of the impacts of different shortage sizes. Although the scale is useful for comparisons within classes, it is much more problematic to make direct comparisons across classes. Thus, a rating of "3" for residential customers is not equivalent to the same rating for business customers.

What can be compared across classes are the rates at which the impacts increase as the system-wide shortage grows. Thus, despite the fact that business and industrial customers experience smaller percentage cutbacks than do residential customers at each level of system shortage, the impacts on these non-residential customers increase more quickly than do the residential impacts. Thus, for example, a moderate 20% overall system shortage would result in residential shortages of about 20%, while business, industrial, and golf course customers would be subjected to about 15% cutbacks. However, according to the non-residential respondents, the impacts of this moderate shortage level are already beginning to grow, particularly for industrial customers.

Similarly a 30% system shortage is reported to affect industrial customers in major ways, whereas residential customers will experience important, but not as serious impacts.

It bears repeating that the highly-summarized results of Table ES-4 are not a substitute for the descriptive material in the body of the report. Instead, they represent an alternative "entry-point" for policymakers into the richer information.

[5] Only those classes for which it is possible to meaningfully differentiate among different shortage magnitudes are shown.

SHORTAGE IMPACTS IN THE INTEGRATED WATER PLAN

As described above, the City of Santa Cruz, in its Integrated Water Plan, will have to determine the appropriate combination of new supplies, enhanced water conservation programming, and future shortages. To inform these choices, this study is intended to provide decision-makers an understanding of the types and magnitudes of hardships that different customer classes will face in the event of various magnitudes of future water shortages.

The City will ultimately have to decide which supplies it wants to develop (and in what sequence and with what timing), with which conservation programs it wants to proceed (and with what level of intensity), and what frequency and magnitude of water shortages it is willing to tolerate. This decision requires that tradeoffs be made among the costs and benefits of these three components. These tradeoffs will be driven by quantitative as well as qualitative information. Information that cannot be quantified is not any less important.

City policymakers must determine what future strategy is best for the community, its residents, and its businesses. This is partly a matter of numbers. For instance, all else being equal, the community is better off if costs and therefore water rates are kept down. But numbers tell only part of the story. For example, to the extent that one resource is anticipated to have greater environmental impacts, that resource may be viewed with less favor even though it is less expensive. To the extent that community values favor one type of water resource over another, that will weigh in that resource's favor, despite the fact that it may be more costly.

Thus, while the customer shortage impacts discussed in this report are generally not expressed numerically, they are critical to the City's decision-making process. The IWP will be forecasting the future water supply reliability associated with particular resource strategies. The reliability is a function of such parameters as the supply characteristics of existing and new supplies, the capacity constraints of transmission and treatment facilities, water rights and instream flow constraints, future demands, conservation savings, etc. While reliability can be expressed in a variety of ways, the key descriptors are the expected frequency and magnitude of future water shortages. Policymakers will be asked to choose among strategy alternatives that have different costs, supply reliabilities, and other characteristics.

The results of this study are designed to enable policymakers to associate different shortage magnitudes with the hardships that these shortages impose on customers. This allows the form of the key tradeoff questions to change. Instead of asking whether the City should spend so many dollars to reduce the expected frequency of an x% shortage by a specified amount, policymakers will be able to ask whether the City should spend those dollars to reduce the expected frequency of a particular set of customer hardships. Instead of focusing on the size of the shortage, the focus is shifted to impacts on customers, which is where it should be.

Table ES-4

ESTIMATED RELATIVE CUSTOMER CLASS PEAK-SEASON SHORTAGE IMPACTS

SHORTAGE CONDITION	PEAK-SEASON SYSTEM SHORTAGE	SINGLE-FAMILY		MULTI-FAMILY		BUSINESS		INDUSTRIAL		GOLF	
		SHORTAGE	IMPACT	SHORTAGE	IMPACT	SHORTAGE	IMPACT	SHORTAGE	IMPACT	SHORTAGE	IMPACT
Mild	**10%**	11%	1	9%	1	4%	1	5%	2	5%	1
Moderate	**20%**	22%	1	19%	1	13%	2	15%	3	15%	2-3
Serious	**30%**	31%	3	27%	3	22%	4	25%	5	25%	4
Severe	**40%**	41%	4	37%	4	27%	4-5	30%	5	30%	4-5
Critical	**50%**	54%	5-6	48%	5-6	33%	6	35%	6	35%	5
Extreme	**60%**	63%	6	56%	6	48%	6	50%	6	50%	6

Key to Shortage Impacts:

1. Little or none
2. Some
3. Intermediate
4. Considerable
5. Major
6. Catastrophic

I. INTRODUCTION

This study has been prepared to provide the City of Santa Cruz with information on the manner in which potential future peak-season water shortages would affect different classes of water consumers in the Santa Cruz Water Department's (SCWD) service area. The intent of this study is not to quantify these impacts, but rather to describe the actions that different customer classes are likely to take to reduce water consumption by specified amounts and the economic and non-economic hardships that these actions would impose on customers.

BACKGROUND AND PURPOSE

The City of Santa Cruz must make a number of critical water supply decisions. The City's water system is highly vulnerable to shortage in drought years when the San Lorenzo River and coastal sources run low. The water system is capable of meeting current demands in normal and wet years. In critically dry or extended dry periods, through, there is insufficient water available from the City's various supply sources to satisfy the community's needs. The storage capacity of Loch Lomond Reservoir is limited and insufficient to carry the system for extended periods of time. This deficiency is expected to worsen over time.

In two previous droughts (1976-77 and 1987-92), the City faced maximum peak-season shortages approaching 30%. In comparable future hydrological events, with increasing demands, shortages will be more severe. Shortages are also expected to become more frequent. By the year 2020, the City could experience supply shortfalls in three out of four years; shortages would occur even under average rainfall and runoff conditions.

In its planning to address these issues, the City has already determined that it is willing to accept some degree of use curtailment to manage future water shortages. Indeed, in its Integrated Water Planning (IWP) process, the Santa Cruz Water Department (SCWD) is attempting to evaluate three potential complementary approaches to addressing the City's current and future water supply needs:

- Enhanced water conservation efforts;
- Periodic demand curtailment due to water shortage;
- Additional water supplies.

The IWP must determine the combination of these approaches that best meets the needs of the citizenry. A decision by the City to permit larger and more future curtailments would mean that future supply and/or conservation projects could be deferred or downsized.

Thus, this study is one of three efforts that have been or are being undertaken as IWP "building blocks." The results described in the following pages will be combined with the results of the Water Conservation Plan and the Water Supply Study to develop the IWP. The study examines six different levels of shortage severity, ranging from a mild (10%) to an extreme (60%) system-

wide peak-season shortage.[6] For each of these, the study looks at likely actions that customers in each customer class would take and the hardships that these actions would impose. The intent is to enable comparisons across shortage levels and between the impacts of different shortage severities and possible investments in new supplies and/or conservation programs.

Generally speaking, the study gathered information on the effects on customers of shortages that last for a single peak season. The focus was not on possible more severe impacts that might result from the cumulative effect of multi-year shortages, although some anecdotal evidence of such cumulative impacts was obtained.

CURTAILMENT STUDY COMPONENTS

The key study components are described in the report sections that follow:

- Section II discusses a priority-based approach to allocating system-wide shortages across customer classes. This approach guides the specific investigation of shortage impacts on each class.

- Sections III through VII describe the shortage impacts on each class. The sections share a common organization:
  - Each section begins with a brief profile of the service class(es).
  - The allocation of system-wide shortages to that class is depicted.
  - The likely actions taken and hardships experienced by the class are then described.

- Section VIII focuses on the manner in which the results of this study should be incorporated into the IWP.

- Section IX summarizes the study results.

The entire study is informed by an extensive literature review, the results of which are described in Appendix A. This review was designed to ensure that the applicable work of others in the field was understood and considered.

[6] The peak season is defined as the months of April through October.

II. A PRIORITY-BASED APPROACHED TO SHORTAGE ALLOCATION

When planning for potential future water shortages, a water supply agency must make three fundamental decisions:

- The manner in which water shortages will be allocated across customer classes;
- The specific voluntary and/or mandatory restrictions that will be imposed on customers in each class to achieve the desired usage reductions; and
- The manner in which the restrictions will be enforced.

The focus of this section is the first of these three decisions, namely how shortages of various magnitudes will be allocated among customer classes. All three of these issues are addressed to some extent in the City's water shortage contingency plan, which is codified in Ordinance 92-10. This report does not examine that ordinance in detail, nor does it make recommendations regarding specific restrictions or enforcement mechanisms.

WATER USAGE PRIORITIES

This report assumes that shortages will be allocated to classes of service based on the classification of end uses into three priorities, which are consistent with those in the ordinance:

4. **Health and safety**. This is the highest priority use. All residential interior and non-residential sanitary uses are assumed to fall under this priority, as is all usage at the wastewater treatment plant.

5. **Business**. This second priority use includes all usage that is related to commercial activity in the city. All non-sanitary uses in the business class are assigned this priority, as is all usage by the agriculture, industrial, golf, municipal, and miscellaneous classes of service.

6. **Outdoor irrigation**. This lowest priority use includes all outdoor usage in the single family, multi-family, UCSC, and large landscape classes.

Under this priority scheme, end uses related to health and safety are assumed to be cut back the least in a water shortage, while irrigation will be cut back the most. The prioritization recognizes the critical importance to the city's economic well-being and the well-being of its citizens of

business activities. While these uses are of a lower priority than health and safety uses, the ranking attempts to shield them from the full brunt of a water shortage. It should also be noted that such outdoor uses as golf course irrigation, agricultural irrigation, and commercial irrigation are all considered to have a business priority.

Table 1 shows the manner in which current peak-season class demands are divided among the three usage priorities.[7] Nearly half of total demands are for "health and safety," with approximately one-fourth each for business and irrigation.

Table 1

CUSTOMER CLASS YEAR 2000 PEAK-SEASON DEMANDS BY USAGE PRIORITY

(MILLIONS OF GALLONS)

CUSTOMER CLASS	USAGE PRIORITY			TOTAL
	HEALTH AND SAFETY	BUSINESS	IRRIGATION	
Single Family	661	--	382	1,043 (37%)
Multi-Family	428	--	173	601 (21%)
Business (incl. Agriculture)	163[8]	415	--	578 (20%)
University of California	97	--	41	138 (5%)
Large Landscape	--	--	135	135 (5%)
Golf Irrigation	--	117	--	117 (4%)
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Waste Water Plant	13	--	--	13 *
Miscellaneous	--	8	--	8 *
TOTAL	1,362 (48%)	736 (26%)	732 (26%)	2,830 (100%)

** Less than 0.5% of total.*

[7] The demand figures in Table 1 and throughout this section are based on the 1998 Water Demand Investigation developed by Maddaus Water Management.

[8] The estimate of business sanitary use assumes 20 gpd per employee for 6 days per week.

Estimates were then made of the degree to which each usage priority will be cut back during hypothetical system-wide peak-season shortages ranging from mild (10%) to extreme (60%). These cutbacks are shown in Table 2. At each level of system-wide shortage, the usage priorities are maintained, with health and safety uses experiencing the smallest shortage, followed by business uses, and irrigation uses. Note that, in order to partially shield health and safety and business uses from the full shortage impact, irrigation uses are cut back substantially. However, due to the relatively small (26%) fraction of total use that is in this lowest priority, the ability to do that is limited.

Finally, based on the Table 1 usage-priority composition of each customer class, the usage-priority cutbacks are transformed into class cutbacks. The results are shown in Table 3.[9] Table 3 also shows the volume shortfalls associated with each shortage condition.

Generally speaking, the overall cutbacks experienced by residential customers are close to the system-wide shortages, as are those for the University of California. Business and industrial customers, on the other hand, are cut back significantly less, while large landscape customers are cut substantially more. As a pure health and safety use, the wastewater plant reductions are smaller than those for any other class.

Table 2
ESTIMATED PEAK-SEASON USAGE-PRIORITY SHORTAGES

SHORTAGE CONDITION	PEAK-SEASON SYSTEM SHORTAGE	SHORTAGES BY USAGE PRIORITY		
		HEALTH AND SAFETY	BUSINESS	IRRIGATION
Mild	10%	0%	5%	30%
Moderate	20%	6%	15%	50%
Serious	30%	14%	25%	60%
Severe	40%	21%	30%	75%
Critical	50%	28%	35%	100%
Extreme	60%	42%	50%	100%

[9] Tables showing additional detail of the class shortage allocation are shown in Appendix B.

Table 3
ESTIMATED PEAK-SEASON CUSTOMER CLASS SHORTAGES
(BASE USE IN PEAK SEASON: 2,830 MILLION GALLONS)

SHORTAGE CONDITION	PEAK-SEASON SYSTEM SHORTAGE	VOLUME UNSERVED (MG)	SHORTAGES BY CUSTOMER CLASS						
			SINGLE FAMILY	MULTI-FAMILY	BUSINESS	U.C.	LARGE LNDSCP.	INDUSTRIAL, GOLF, & MUNICIPAL	WASTE WATER PLANT
Mild	**10%**	**280**	11%	9%	4%	9%	30%	5%	0%
Moderate	**20%**	**560**	22%	19%	13%	20%	50%	15%	6%
Serious	**30%**	**840**	31%	27%	22%	28%	60%	25%	14%
Severe	**40%**	**1120**	41%	37%	27%	37%	75%	30%	21%
Critical	**50%**	**1400**	54%	48%	33%	49%	100%	35%	28%
Extreme	**60%**	**1680**	63%	56%	48%	60%	100%	50%	42%

III. RESIDENTIAL CUSTOMER SHORTAGE IMPACTS

RESIDENTIAL CLASS PROFILE

Currently, the population of the Santa Cruz Water Department (SCWD) service area is estimated at 90,000. These customers are classified as either single family or multi-family. Single-family customers are those that live in units (generally single-family homes or condominiums) that are individually-metered. Multi-family customers live in apartment buildings or complexes in which the residential units are not individually metered. Approximately 51,000 of the residential population lives in single-family units and 39,000 in multi-family units.

SCWD serves approximately 17,700 single-family and 2,500 multi-family accounts. The annual demand of the single family customers is about 38% of the system total. The annual multi-family demand is about 24% of the total. Thus, residential customers as a whole account for close to two-thirds of total annual system demand.

Peak-season usage for single-family customers is about 63% indoors and 37% outdoors. For multi-family customers, 71% of peak-season usage is indoors and 29% outdoors. Although Santa Cruz outdoor usage is a substantial portion of summer consumption, it represents a much smaller portion of summer water use than in many other California jurisdictions, reflecting differences in climate, plant material, demography, and lot size. In addition, Santa Cruz residential customers have already incorporated many behavioral and equipment changes into their normal outdoor irrigation patterns.

Over the year, the typical single family account uses about 225 gallons per day; this rises to 275 gallons in the peak (April-October) season. Peak-season daily indoor usage is about 175 gallons; outdoor daily usage in the peak season is about 100 gallons. On a per-capita basis, single-family customers currently use about 60 gallons daily indoors and, during the peak-season, about 35 gallons per day outdoors.

Corresponding usage figures for the typical multi-family account about 950 gallons per day over the year and 1125 gallons per day in the peak season. (This equates to about 150 gallons and 175 gallons per multi-family household per day.) Per-capita peak-season multi-family daily usage is about 53 gallons indoors, and 21 gallons outdoors.

RESIDENTIAL PRIORITY-BASED SHORTAGE ALLOCATION

Table 4 extracts the shortage impacts for the two residential classes from Table 3.

Table 4

PRIORITY-BASED SHORTAGE ALLOCATIONS TO RESIDENTIAL CUSTOMER CLASSES

SHORTAGE CONDITION	SYSTEM SHORTFALL	OVERALL CLASS SHORTAGES		BASIS	
		SINGLE-FAMILY	MULTI-FAMILY	INDOOR REDUCTION	OUTDOOR REDUCTION
Mild	10%	11%	9%	0%	30%
Moderate	20%	22%	19%	6%	50%
Serious	30%	31%	27%	14%	60%
Severe	40%	41%	37%	21%	75%
Critical	50%	54%	48%	28%	100%
Extreme	60%	63%	56%	42%	100%

LIKELY ACTIONS BY RESIDENTIAL CUSTOMERS

Each residential customer will respond differently to a shortage. Within the constraints of the City's shortage management policy, each customer will presumably choose actions to minimize hardship. While actions by individual customers cannot be predicted, some general conclusions regarding the types of actions that most single family and multi-family customers are likely to take can be drawn.

The actions to be taken are guided by the priority-based class allocations described above, which provides estimates of the reductions to be achieved by the two residential classes in six different shortage scenarios. To better understand the actions likely to be taken to achieve these reduction levels, the following sources were relied on:

- Evidence from past California droughts
- Focus groups with Santa Cruz residential customers
- An assessment of shortage impacts on Santa Cruz residential landscapes

The following discussion summarizes the relevant findings from each of these sources.

Evidence From Past California Droughts

There has been little systematic research on the specific actions taken by residential customers during California's 1976-77 and 1987-92 droughts. One key exception is the work of Baumann and Opitz regarding responses in Southern California during the 1987-92 drought,[10] which found that customers were more likely to modify water-use behaviors, rather than make structural changes. Often-mentioned behavior changes include reducing the frequency of clothes washer and dishwasher use, decreasing lawn watering, and reducing outdoor surface washing. Simple structural changes, such as leak repairs, use of low-flow showerheads, and use of toilet displacement devices were also fairly frequent.

Bruvold found that most respondents reported only minimal hardship from reducing water use by as much as 1/3 during the 1976-77 drought.[11] Following an evaluation of impacts of and responses to the 1976-77 drought, the California Department of Water Resources concluded that "[t]he experience of 1977 clearly showed that Californians can carry on nearly all domestic activities, with little more than a minor crimp in lifestyles, with a rather substantial reduction in water consumption. Few people really suffered from water shortage; they changed habits to 'waste' less." [12]

Of course, these results must be carefully interpreted. Aside from the general caveats about differences among jurisdictions, water conservation by residential customers may have "hardened" demand considerably since earlier droughts, making it more difficult to achieve additional drought responses. "Demand hardening" is defined as the diminished ability or willingness of customers to reduce their demand for water during a shortage. While the empirical evidence of significant demand hardening is spotty, it cannot be completely discounted. As described below, Santa Cruz residential customers appear to believe that demand hardening is a potentially important issue.

Residential Customer Focus Groups

Two Santa Cruz residential customer focus groups were conducted, one each with single-family and multi-family residents. The manner in which the focus groups were conducted and the findings are described in detail in a separate document, which is included as Appendix C. Participants were successively asked to describe the actions they would take and the types and levels of hardship these actions would impose if they had to reduce their summer usage by 10%, 30%, and 50%, which roughly correspond to "mild," "serious," and "critical" system-wide shortages. Participants were then presented with some information on typical residential water

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[10] Baumann, Duane and Eva Opitz, "Measurement of Conservation Attitudes and Behaviors: Trends in Southern California." Proceedings of Conserv 93: The New Water Agenda. Las Vegas. 1993

[11] Bruvold, William H. "Residential Response to Urban Drought in Central California", Water Resources Research, Vol. 15, No.6, December 1979.

[12] California Department of Water Resources, "The 1976-77 California Drought: A Review." Sacramento, CA., 1978.

usage patterns after which they were asked the same set of questions in order to see if the additional information resulted in changes in responses.

Key findings from these focus groups include:

- The common wisdom in shortage management in California and elsewhere has been that outdoor watering will take the lion's share of a shortage. The single-family focus group participants reported that, in mild shortages (requiring a 10% usage reduction), they would rely more heavily on behavioral changes, such as shorter or less frequent showers, and reductions in toilet flushing, clothes washing, dishwashing, faucet use, and washing of outdoor surfaces. For more severe shortages, changes in outdoor irrigation are reported more frequently, as are substitution activities[13] and capital replacement. (This is not inconsistent with the findings of Baumann and Opitz, who found that outdoor watering reductions were one of many behavioral changes reported by Southern California customers during the 1987-1992 drought.)

- Perhaps because of the smaller size of the multi-family focus group and the smaller number of water-reduction actions available, the results for multi-family participants are less clear. Not surprisingly, multi-family customers did not report any capital investments.

- Not unexpectedly, participants report increasing hardship as the magnitude of the shortage increases. Perhaps more surprisingly, even at a 50% shortage level, only about one-fourth of single-family and 40% of multi-family participants reported that expected actions would result in "considerable" hardship. However, the comments of single-family participants appear to indicate a much higher level of concern and, in some cases, anger, at the prospect of having to endure large future shortages.

  Moreover, participants were not told how the shortage would be managed or what penalties would be imposed for not achieving the target reduction levels. As will be discussed below, the imposition of rationing at higher shortage levels will likely result in a level of customer anxiety not captured in the focus group responses.

- Milder shortages are expected to result primarily in inconvenience, while more severe shortages are expected to result in many more economic, aesthetic, or health and safety impacts.

- Several single-family participants articulated a concern that, since they have already "hardened" their demand by adopting water-conserving behaviors or technologies,

[13] Substitution includes any action which physically substitutes for water use in the home. Examples include:
- Drinking bottled water
- Showering at health club
- Washing clothes at laundromat

they would be unfairly burdened if asked to reduce their demand by the same percentage as their non-conserving neighbors.

- It appears that the provision of the basic water usage information allayed some of the concern of participants, and resulted in reduced hardship expectations. Moreover, participants uniformly felt that the information was useful and would help customers respond to a shortage. Additional study of the amount, content and timing of information to be provided to residential customers to assist them in better coping with future shortages is clearly warranted.

The residential customer focus groups provide some important clues as to how residential customers would behave, and the hardships they expect in the face of different levels of shortage severity. However, the inherent limitations of focus group research[14] combined with the difficulty of the task being asked of the participants render the results at most indicative of what might be expected from water customers.

Residential Landscape Impacts

The study analyzed the impacts of different curtailment levels on outdoor landscaping. The details of that analysis is described in Appendix D. The analysis, based on a drive-by survey performed by horticultural experts, estimated the extent of landscape loss that single-family residential customers in different parts of the service area would experience as a result of 30%, 65%, and 100% peak-season reductions in outdoor watering, corresponding to "mild," "serious," cal/extreme" system shortages.

The analysis examined single-family residences in six representative census tracts.[15] Six residences were evaluated in each tract. For each of the 36 residences, a sidewalk assessment was performed, focusing on the landscape that was visible. Inferences were then drawn about back and side yards that were not visible from the street.

Landscapes were divided into four components as follows:

- Turf
- Shrubs
- Trees
- Intensively gardened areas, which include flower beds, vegetable gardens, etc.

[14] Most notably, as is typical of focus groups, the participants were not statistically representative of the population of the Santa Cruz Water Department's service area.

[15] Appendix D includes a census tract map.

For each component, the percentage loss in value at each of the three water reduction levels was estimated. The loss in value can be thought of as the percentage of plants that owners or landscape professionals would choose to replace due to the plant's severely degraded or dead condition. Losses vary over the city and depend upon species type, soil type, soil conditions, and plant condition.

Table 5 shows the percentage loss in value associated with the three outdoor curtailment levels for each landscape component in each census tract.

Table 5
AVERAGE PERCENT LOSS OF LANDSCAPE COMPONENTS BY CENSUS TRACT

CENSUS TRACT	30% OUTDOOR CURTAILMENT				65% OUTDOOR CURTAILMENT				100% OUTDOOR CURTAILMENT			
	TURF	TREES	SHRUBS	INTENSIVE	TURF	TREES	SHRUBS	INTENSIVE	TURF	TREES	SHRUBS	INTENSIVE
1001	30%	12%	8%	32%	70%	45%	23%	68%	90%	67%	41%	85%
1002	16%	11%	7%	28%	54%	34%	29%	83%	100%	54%	44%	100%
1213	20%	10%	8%	10%	41%	26%	28%	55%	75%	45%	53%	80%
1215	12%	2%	2%	20%	34%	9%	19%	50%	64%	17%	29%	80%
1006	24%	5%	4%	16%	52%	20%	18%	38%	80%	44%	40%	67%
1005	22%	0%	7%	36%	51%	0%	32%	58%	80%	0%	50%	70%
Average	**21%**	**7%**	**6%**	**24%**	**50%**	**22%**	**25%**	**59%**	**82%**	**38%**	**43%**	**80%**

Of course, the same percentage loss of two landscape components may have very different absolute values. While the valuation of landscape components is subjective and will vary from customer to customer, for purposes of this analysis, turf and intensively-gardened areas are valued at their replacement costs, which are estimated at about $5 and $1 per square foot respectively. Shrub replacement costs are also in this range, while tree replacement ranges from $135 to $300 per tree. However, for trees, and to a smaller extent, shrubs, the replacement cost understates the true value to the customer, since neither of these can be quickly restored to their pre-shortage state (e.g. one cannot purchase a mature tree). Value estimates for mature trees have ranged from $2,500 to $4,000.[16]

Thus, the four landscape components are assumed to generally be valued in the following order (from lowest to highest):

1. Intensively-gardened areas
2. Turf
3. Shrubs

[16] Estimates from personal communication with Marylee Guinon, Sycamore Associates.

4. Trees

Moreover, turf and intensively-gardened areas require the highest volumes of water.

While each residential customer will allocate the outdoor curtailment differently, it is likely that residential customers can reduce their overall loss by shifting water among uses. For example, water usage could be shifted from intensively gardened areas to turf or from turf to trees. Of course, the ability to exercise this flexibility decreases as the outdoor curtailment increases.

The following conclusions can be drawn regarding residential outdoor curtailments:

- Landscape losses associated with 30% reductions are manageable. Losses at a 65% outdoor-curtailment level are harsh, while losses at 100% curtailment are quite severe.

- Because of the variety of species type, soil type, soil conditions, and plant condition across the City and the differing levels of baseline maintenance of those landscapes, average losses for any given level of curtailment vary considerably across census tracts for each landscape component. For example, turf losses at a 65% curtailment level range from 34% to 70%, while tree losses range from zero to 45%.

- Moreover, since homes within census tracts are far from homogeneous, there is a wide range of losses within each tract.

- For any level of curtailment, turf and intensively-gardened areas experience the greatest percentage losses. Trees and shrubs, which are generally more drought-tolerant, experience smaller reductions. However, even these hardier categories experience significant losses when watering is substantially reduced or eliminated.

- Because of the intrinsically greater value of trees and shrubs, they may, in many cases, experience greater absolute losses even though the percentage losses are smaller. By wisely allocating limited available outdoor water, residential customers can significantly reduce their overall landscape losses.

Expected Actions

Based on the foregoing information, the City's past drought experiences, and professional judgment, following are descriptions of the typical actions that residential customers would take at each of the six shortage levels.

Mild Shortage (10% Peak-Season Curtailment)

Residential customers would be asked to reduce their outdoor watering. Moreover, the hours of the day during which watering is permitted would be restricted. As a result, some customers

would avoid planting and/or delay the installation of new landscaping. Those with automatic irrigation systems would need to re-program. Some customers may purchase new irrigation equipment, such as timers, soaker hoses, and even drip systems.

Outdoor washing would likely be prohibited. Patios, driveways, porches, and walkways would be broom cleaned.

Some customers would probably reduce their indoor water use for those end uses where cutbacks are relatively easy. Likely candidates include reduced faucet use and reduced shower times. A smaller fraction of residential customers would more actively save water indoors to increase the availability of water for outdoor irrigation.

The City would enforce a prohibition on water waste, with emphasis on customer education. This would raise many customers' awareness of how they are using water inside their homes, and would cause many to adjust their behaviors. Some would install faucet aerators, new showerheads, or devices in toilets; others would repair leaks more quickly

Moderate Shortage (20% Peak-Season Curtailment)

As was the case in 1991, it is expected that Santa Cruz would not have to impose rationing requirements on water customers to achieve this level of cutback. Instead, residential customers would be encouraged to more strenuously reduce outdoor watering and, according to the focus group results, single-family customers would begin to undertake such reductions more actively. Outdoor watering would be permitted only on certain days of the week and during specified times of day. This would require further re-programming of automatic sprinkler systems, and perhaps in some cases, replacement of these systems. Many home gardens would go unplanted or be reduced in size. Lawns would begin to show some stress, but more valuable trees and shrubs would likely be protected. Purchases of new plant material would decline significantly, and some increase in the installation of drip irrigation systems could be expected. Outdoor washing of driveways, walkways, patios, and porches would continue to be prohibited.

Pool and spa maintenance would likely be deferred and fountains would be turned off. The frequency of reports of water waste by neighbors would increase. Residents with leaking or broken irrigation systems would be required to immediately make repairs.

At this level of shortage, it is likely that many households would choose to reduce their indoor water consumption, including faucet use and showering time; some would extend this to also reduce toilet flushing and clothes and dish washing. Some customers would probably be motivated to replace older plumbing fixtures. More attention would be paid to repairing leaks in various plumbing fixtures.

Apartment managers and home-owner associations would reduce the outdoor watering of common areas and appeal to residents to save water.

Serious Shortage (30% Peak-Season Curtailment)

At this shortage magnitude, it is assumed that rationing would be in effect. Under the City's rationing plan, residential customer allotments are based on family size or, in the case of some multi-family complexes, on number of dwelling units. This type of rationing plan is generally thought to be more equitable, as it does not penalize customers for their prior conservation efforts. One important implication of this type of rationing is that some residential customers would be required to reduce usage to comply with the allotment levels and avoid penalties, while others would not. Larger single-family customers, who typically have larger and/or more water intensive landscapes, are more likely to exceed the allotment than are smaller households. This is consistent with the Task 3 prioritization of end uses, in which outdoor watering has the lowest priority.

This is not to say that smaller customers would not respond. The City's prior drought experiences strongly indicate that all customers will respond to a rationing situation even if their own usage falls well below their allotment. Part of this is due to a desire to help the City deal with the crisis. Part of it seems to be due to smaller customers having little knowledge of how close their usage is to the allotment. In any event, what can be said with some certainty is that most customers would reduce their usage, but those larger customers with more extensive landscapes would likely reduce by larger amounts under the threat of financial penalties.[17]

The discussions of expected water-savings actions at this and higher shortage levels generally address typical impacts across the residential classes. Some broad distinctions between impacts on "larger" and "smaller" customers are drawn.

At a 30% level of shortage, outdoor watering reductions would become more significant and more widespread, with turf and intensively-gardened areas showing serious damage, and trees and shrubs showing some damage. Damage to landscapes can be expected to be more severe for larger customers than for smaller customers. Little planting or purchases of plant material would occur, and more households would install water-efficient irrigation systems.

Most or all households would also reduce their indoor water usage, perhaps by a significant amount, affecting virtually all end uses. This would be even more likely for larger single-family accounts with usage significantly above the allotment.

Apartment managers and home-owner associations would appeal to residents to save water indoors and out. It is likely that indoor usage in multi-family residences will be more significantly affected, because of the higher proportion of multi-family usage that is indoors. Leak repair would become more important and more customers would install water-efficient fixtures, such as showerheads, faucet aerators, or ULF toilets.

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[17] Multi-family customers will typically pass penalties through to their tenants, thereby diluting the financial incentive to stay within allotments.

Severe Shortage (40% Peak-Season Curtailment)

At this and higher levels of shortage, it is assumed that rationing allotments would decrease as a function of shortage magnitude. Most households would find it necessary to take substantial actions to meet these reduced rations. The typical household would be able to preserve most of the valuable trees and shrubs in its yard; turf and intensively-gardened areas would generally be sacrificed. However, customers with large landscapes would not have sufficient water in their allocation to protect trees and shrubs. Many of these valuable plants would be lost. Customers with smaller landscapes may find it necessary to install drip irrigation, use gray water, or take other serious actions to stay within their ration.

Indoor usage would be severely-affected, with short showers and unflushed toilets becoming the norm. Some households would begin to use gray water for toilet flushing in addition to outdoor watering. More would resort to significant investments in water-efficient fixtures or appliances. Leak repair would become essential. Multi-family customers would be particularly susceptible to these indoor reductions. In some cases, common laundry rooms and pools would have to be closed.

Some customers would switch to washing cars, doing laundry, or even showering off-site to preserve their allotment. Others might begin to use paper or plastic products to minimize dishwashing.

More customers would be facing excess use fees, as those that are unable, or unwilling, to stay within their rations will pay penalties. Some with repeated penalties would face the installation of a flow restrictor on their water service.

Critical Shortage (50% Peak-Season Curtailment)

Allotments would be further reduced. It is likely that the City would severely limit or ban outdoor watering. Turf and intensively-gardened areas would be lost, as would a significant percentage of trees and shrubs. Native species and those species adapted to California's Mediterranean climate would have the best chance of survival.

While uses of water necessary for human health and sanitation would be emphasized, practically every household would need to take actions to reduce water use indoors. Toilet flushing would be used for solid waste only. Shortened or "navy" showers would be the norm. Baths would be less frequent and filled only partly full. Laundry would get washed less often. Many would experience sewer drain line clogging and need to hire a plumber as a result of putting less flow down the drain. More households would recycle bath, dish and laundry water for toilet flushing or minimal landscape maintenance, even though the available volume of such gray water would diminish. A small portion of customers may choose to purchase water from outside sources to help keep plants alive.

More people would be subjected to fines if they developed leaks or didn't take the crisis seriously. Repeat offenders would have flow restrictors installed or face service shut-off. The number of fines levied and appeals cases would mushroom.

Extreme Shortage (60% Peak-Season Curtailment)

At this level of shortage, all outdoor watering would cease, resulting in even more loss of valuable trees and shrubs. Indoors, residential customers would be forced to be extremely conscious of every gallon used. Urine would no longer be flushed. Showers would be minimal. Cooking water would frequently be saved for reuse elsewhere. Buckets of collected water would become prevalent. Even clothes washer rinse water would be collected for other household needs.

Use of bottled water would become more commonplace. Reports by neighbors of water waste would become very numerous, as would appeals of rationing allotments. Rationing penalties would be more numerous and severe. Installation of flow restrictors and shut-offs by the City would occur more frequently.

HARDSHIPS IMPOSED BY CUTBACKS

As difficult as it is to predict the actions that would typically be taken by residential customers to cope with a shortage, it is even a more thorny problem to describe the hardships these actions would impose on customers. In this context, the word "hardship" includes both economic and non-economic losses experienced by customers. Because the degree of "hardship" is, in large part, a matter of customers' personal perception, their depiction is necessarily qualitative. The primary data relied on for Santa Cruz customer perception is from the focus groups. That is supplemented with the limited reports of hardship experiences in the literature, past Santa Cruz experience, and professional judgment.

It is very possible that, particularly in severe shortages, water rates in Santa Cruz will increase and/or be restructured. This study did not attempt to assess the expected type and magnitude of these rate changes. However, the hardships associated with the customer actions described above would likely be accompanied by some economic impacts associated with increased water bills.

Moreover, although hardships are very customer-specific, they are likely to be unevenly distributed across income levels.[18] As noted above, rationing is more likely to have a direct impact on homes with larger lots; these customers tend to have higher incomes and to devote large amounts of water to low priority uses. There are also several reasons to expect low income households to feel greater effects, particularly as shortage severity increases. They include:

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[18] This impact was noted in Santa Barbara's earlier drought experiences. See Spectrum Economics and Sycamore Associates, *The Costs of Water Shortages: Case Study of Santa Barbara*. 1991

- Low-income families are less able to afford to invest in water-saving technologies.

- Low-income families are more likely to live in multi-family dwellings and, therefore, have less control over their water consumption. Landlords can simply pass increased water bills or rationing penalties through to their tenants.

- Low-income families will be more affected by water rate increases. Water currently accounts for a larger portion of the household budget for low-income families than for residential customers as a whole.

The extent of hardship to low-income households depends in part on the degree to which the City's management of the shortage attempts to mitigate this hardship as well as the other forms of assistance the City offers to its low-income residents.

Expected Hardships

Following are discussions of the typical hardships that can be expected at each of the six levels of shortage.

Mild Shortage (10% Peak-Season Curtailment)

At this level of shortage, the focus groups, the literature, the landscape review, and the City's past drought experience all point to minimal hardship being experienced. In fact, 65%-70% of the actions anticipated by single-family focus group participants and 60%-90% of actions reported by multi-family participants to result from a 10% summer cutback were characterized as imposing "little or no" hardship.[19] Moreover, the vast majority of the impacts reported by both classes were described as an "inconvenience," with very few having either "economic" or

Moderate Shortage (20% Peak-Season Curtailment)

Some residential customers would begin to view some of the actions as imposing "some" hardship. In particular, while outdoor economic losses would be minimal, customers would begin to experience some reduced enjoyment of their yards as lawns begin to brown and, perhaps, outdoor hard surfaces are not as clean. The general aesthetic feel of neighborhoods would also begin to decline. In addition, curtailed use of pools and spas would reduce the quality of life for some households.

Economic losses would be experienced by those customers with defective irrigation systems that would have to be repaired.

[19] An even larger fraction of actions are deemed to impose "little or no" hardship as customers are given more information regarding their water usage patterns.

Indoor hardships would be minimal, and would probably be manifested in inconveniences associated with shorter showers, less frequent toilet flushes, and full clotheswasher and dishwasher loads. Leak repair would also be an inconvenience and, in some cases, a minor expense. Residents in higher-density areas, many of whom have low incomes, would have to reduce their indoor uses more.

Serious Shortage (30% Peak-Season Curtailment)

With the imposition of rationing, the City's past drought experience points to an important hardship that is not easily quantified, but is real nonetheless. Rationing causes an overriding anxiety among customers that is simply not present with the specific restrictions associated with less severe shortages. The "tone" of the shortage changes with the specter of exceeding the allowance and incurring penalties.

This phenomenon is borne out by the City's experience in 1990, when overall usage had to be reduced by 24% and rationing was imposed. Calls to the Water Department skyrocketed, many from smaller customers whose usage did not approach their allotment. Multi-family customers complained vigorously about their allotments; even after the allotment formula was changed, many multi-family customers felt that they were being treated unfairly relative to single-family households. Tenants expressed concern about landlords passing through excess-use fees.

The Water Department was overwhelmed with variance applications. The Drought Board worked long hours to hear cases. For some customers having difficulty paying penalties, payment plans had to be devised.

The anxiety felt by some customers appears to be due primarily to a lack of knowledge of their water usage and how it compared to the allotment quantities. Thus, to some extent, the stress could be eased by the provision of better information. However, it is clear that, in addition to the additional water-saving actions that must be taken, rationing changes the emotional impact of a shortage.

At a 30% shortage level, focus group participants reported a clear shift from actions that impose "little or no" hardship to those that would impose "some" and in a few cases, "considerable" hardship.

Moreover, participants reported a clear shift from inconveniences to aesthetic and, in the case of single-family customers, economic impacts.[20] Both residential classes report that some (8-12%) of the actions taken would affect health and safety.

[20] Recall that the focus group results did not reflect potential economic impacts of penalties for exceeding rationing allotments or of possible water rate increases.

Outdoor hardships would include brown lawns and, in some cases, damage to more valuable trees and shrubs. In addition, the inability to plant and enjoy gardens would be a hardship to some residents, as would the cost of installing efficient irrigation systems.

Indoors, the need to significantly reduce water usage would cause customers to have to deal with shorter showers, sometimes unflushed toilets, and less frequent washing of clothes and dishes. In addition, considerable attention would have to be paid to the onerous (for some) task of diagnosing and repairing leaks.

Severe Shortage (40% Peak-Season Curtailment)

More customers would face economic penalties if they do not substantially reduce their consumption. Many multi-family complexes would pass through penalties to tenants regardless of the water use reductions achieved by individual households.

More of the actions taken to reduce usage would impose "considerable" hardship on customers. Fewer hardships would be perceived as mere "inconveniences"; more would be considered to affect health and safety.

The widespread browning of lawns and the inability to enjoy flower and vegetable gardens would be felt by most customers. Short showers and unflushed toilets would be a burden for many customers, as would the necessity to install new fixtures and appliances. Some would experience the significant inconvenience and/or economic impact of going off-site to consume water for some end uses.

Some multi-family residents would lose the use of their common pools or laundry rooms.

In general, at this level of shortage, residential customers' lifestyles would be significantly affected.

Critical or Extreme Shortage (50%-60% Peak-Season Curtailment)

A shortage of this magnitude would likely result in water use becoming a disagreeable preoccupation for many, if not most, residential customers. Most water-saving actions would impose "some" or "considerable" hardship. More of these hardships would affect health and safety; few would only be an inconvenience.

Many customers would have to helplessly watch valued portions of their landscapes die. As showers are shortened and clothes washing and dishwashing frequency reduced, there would be less gray water available to preserve landscapes. Indoors, the distasteful prospect of constantly-unflushed toilets would face most households, as would the need to take very short showers and, perhaps, the need to wear clothes one or two extra times before they are washed. Some of these may adversely affect health and safety.

Potential – and, in many cases, actual – excess-use penalties would impose emotional as well as economic hardships. The need to deal on a regular basis with the City "bureaucracy" would be a burden on many, as would the need to report neighbors or the concern about being reported for perceived excess use.

This level of shortage would cause major lifestyle changes.

CONCLUSIONS

It is very difficult to predict the specific actions customers would take in the event of water shortages or the hardships that these actions would impose. The foregoing descriptions are not meant to be precise depictions. Rather, they are intended to provide a sense of the manner in which different shortage levels would affect residential customers.

In general, it is likely that Santa Cruz residential customers could deal with system shortages in the 10%-20% range with little difficulty. At about the 30% level, as rationing becomes necessary, impacts become more significant. Chief among these is the anxiety accompanying rationing and its associated administrative and economic impacts. Effects on households of a 40% system shortage would be serious, with important lifestyle changes.

Catastrophic shortages in the 50%-60% range would raise customer concern about everyday water use to an unparalleled level. They would also impose major and burdensome lifestyle changes, some of which could well affect basic health and safety. There would be a greatly-increased level of conflict between customers and the City government to resolve issues and complaints. There may also be increased levels of conflict among neighbors and even within families, as water becomes a very scarce resource.

IV. BUSINESS AND INDUSTRIAL SHORTAGE IMPACTS

BUSINESS AND INDUSTRIAL CLASS PROFILE

SCWD currently serves about 1900 business (commercial) accounts and 45 industrial accounts.[21] Business customers annual demand is about 715 million gallons, or about 20% of the system total. Industrial demand is 6% of system total, with close to 90% of industrial demand coming from a single customer. Peak-season (April-October) demands for these customer classes comprise about the same fractions of system totals as do annual demands. Outdoor use for business customers is about 25% of the class total consumption. For industrial customers, this percentage decreases to 12%.

Commercial and industrial (CI) accounts employ about 45,000 people in the SCWD service area.

BUSINESS AND INDUSTRIAL CLASS PROFILE

Table 6 summarizes the cutbacks faced by business and industrial customers under the priority-based shortage allocation.

LIKELY ACTIONS BY BUSINESS AND INDUSTRIAL CUSTOMERS

While every customer will respond differently to a shortage, this is particularly true of CI customers, who are very diverse. Different types of businesses use water in very different ways. Moreover, water for many CI customers is a key input to the production process, and so has direct economic impacts on the business and, perhaps, on the community.

Within the constraints of the City's shortage management policy, each customer will presumably choose actions to minimize economic and non-economic hardship, with economic considerations (i.e. the health of the business) taking precedence. While actions by individual customers cannot be predicted, an attempt is made to draw some general conclusions regarding the types of actions that customers in each CI sector are likely to take.

The literature provides almost no guidance in this regard. What little discussion there is of non-residential drought response deals with overall economic impacts rather than specific actions by sector. The relevant results of that literature review will be summarized in the following section, which addresses hardships.

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[21] Industrial accounts exclude the University of California.

Table 6

PRIORITY-BASED SHORTAGE ALLOCATIONS TO BUSINESS AND INDUSTRIAL CUSTOMERS

SHORTAGE CONDITION	SYSTEM SHORTFALL	COMMERCIAL SHORTAGE	INDUSTRIAL SHORTAGE	BASIS	
				SANITARY USE REDUCTION	NON-SANITARY REDUCTION
Mild	10%	4%	5%	0%	5%
Moderate	20%	13%	15%	6%	15%
Serious	30%	22%	25%	14%	25%
Severe	40%	27%	30%	21%	30%
Critical	50%	33%	35%	28%	35%
Extreme	60%	48%	50%	42%	50%

A mail survey of Santa Cruz commercial customers and a series of interviews with a subset of the survey respondents were used to better understand the actions likely to be taken to achieve these reduction levels.

Results of CI Customer Survey and Interviews

As was the case for the residential focus groups, the discussion in this section is based on self-reports by survey and interview respondents. While the residential focus groups were supplemented by a significant amount of prior research on indoor residential end uses and a survey of shortage impacts on Santa Cruz residential landscapes, this is not the case for the CI impacts. The scope of this study did not include any independent verification of the CI self-reports.

The development and administration of the survey was coordinated with the Economic Development Committee of the Santa Cruz Area Chamber of Commerce. The Committee:

- Helped identify specific businesses and contacts for survey mailing;
- Reviewed and edited the survey instrument prior to mailing; and
- Transmitted the survey with a Chamber cover letter.

The survey and interviews addressed the following major CI customer sectors:

- Hospitals
- Hotels/Motels
- Manufacturers
- Malls
- Medical Offices

- Parks
- The "Green" Industry
- Restaurants
- Retailers
- Schools
- Other

Due to study limitations and small Santa Cruz populations in some of these sectors, the numbers of survey respondents and interviewees were generally small.[22] Thus, just as was the case for the residential class, the following conclusions should be viewed as general indicators of actions that customers in each CI sector would report. There is considerable heterogeneity within each sector. Therefore, actions taken by each individual customer will probably differ.

The mail survey asked each respondent to identify the actions that would be taken to achieve peak-season reductions of 15%, 25%, and 35%, roughly corresponding to "moderate," "serious," and "critical" system shortages. Respondents were also asked to estimate the economic and non-economic hardships that each action would impose on their business. A copy of the survey instrument is included as Appendix E.

The interviews with one or a few representatives of each sector sought to clarify and supplement the interview responses.

Following are the results for each sector.

Hospitals

Hospital water usage is largely indoor, although each of the three respondents[23] reported significant landscape watering. The indoor uses clearly have a direct link to health and safety concerns and there is a perception that there is little latitude in indoor use and that sanitation cannot be compromised. (Both of the major hospitals in the area use an off-site commercial laundry, so their water-reduction actions would not include this important end–use.)

Outdoor use is seen to be the major discretionary use, although the interviewees appeared to have limited knowledge of their outdoor usage.

Respondents reported that the major actions to achieve a 15% reduction would be outdoor, although the interviews revealed that outdoor cutbacks alone might not be sufficient. Respondents did not have a clear idea of how they would achieve a 25% reduction, let alone a 35% cutback. One respondent commented that a 35% shortage would "shut us down."

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[22] Eighty-six surveys were mailed; 55 responses were received. Nine interviews were conducted with a total of 18 people.

[23] One of the three respondents was a skilled nursing facility.

The full-service hospital representative felt that a 25% shortage would result in rescheduling or cutting back non-emergency services. A 35% cutback would result in limiting service to emergency cases only, sending other cases to neighboring communities. (As discussed below, this would impose considerable hardship on patients.) At both these shortage levels, respondents believed that outpatient services would have to be closed down.

One hospital representative observed that loss of water service was the Y2K impact that was feared most.

Hotels/Motels

Major end-uses for this sector include sanitary uses by guests, clothes (linen) washing, landscape irrigation, and swimming pool topping off and deck washing. Respondents believed that a 15% cutback could be achieved primarily with landscape watering reductions, although some doubt about this was expressed for properties with little landscaping. At 25%, respondents mentioned possibilities of making linen changing for multi-day stays a guest option, reducing pool deck washing, and/or closing the pool/spa. At this level, the interviewees expressed considerable doubt as to whether they could avoid reduced occupancy rates. A 35% shortage elicited some comments such as "are you wanting us to go out of business?". Pool closure was felt to be almost a certainty at this level of cutback which at least one respondent felt would reduce occupancy by 50%. All respondents mentioned the difficulty of controlling guests' water use behavior.[24]

Manufacturers

Survey responses were received from three manufacturers, one large semiconductor plant and two much smaller customers producing bottled water and concrete respectively. All three indicated production cutbacks would be necessary to achieve even a 15% cutback. Landscape irrigation reductions were mentioned at all shortage levels, as was improved water recycling.

The responses by the semiconductor manufacturer are of particular interest. This customer is one of the City's largest water users and a large employer as well. This customer has completed two major water reclamation projects, and is about to embark on a third. According to the respondent, the third phase will carry some risk as it involves reclaiming rinse water to use in the front end of production. That risk can be mediated to some degree through instrumentation. Altogether, these phases will require an investment of $3.5 million over 3 years and will reduce projected water consumption from 600,000 to 360,000 gallons per day.[25] The respondent indicated that the investments have been made largely for environmental reasons and that the payback on the last project will be 5 years, longer than normally accepted by industry for this type of investment.

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[24] Some hotels and motels have already retrofitted guest rooms with ultra-low-flush toilets. Those that have not may be able to achieve greater savings during a water shortage through toilet retrofit.

[25] Current daily usage is estimated at 520,000 gallons. The 600,000 figure reflects expected future increased production levels.

In addition to actions already taken, the company representative described three possible further actions that would have to be taken:

- Eliminate landscape irrigation (estimated 1.25% water use reduction).
- Limit production by 3.75%, 13.75% or 23.75% respectively for 15%, 25%, and 35% cutbacks. The two larger production cutbacks are estimated to result in layoffs of 10% (62 employees) and 20% (124 employees).
- Treat and recycle wastewater even more aggressively than the planned third reclamation phase. This would cost an estimated $2.5 million for engineering and construction. There would also be additional yearly costs for waste disposal due to increased concentrations. Such a project, were it approved by corporate headquarters, would make this plant the only one in the U.S. to have such as system. Its effectiveness is uncertain.

The representative expressed some certainty that the corporation would close the plant if 35% reductions were necessary. There was also some fear that, even at a 25% shortage level, the corporation would slow investments in technology upgrades, which would be the "kiss of death" for the plant.

Finally, the representative believes that the near 50% reductions already achieved should exempt the plant from future drought curtailments.

Malls

The single respondent indicated that a 15% cutback could be achieved through reducing landscape irrigation and outdoor washing. A 25% shortage would require further irrigation and indoor and outdoor washing reductions, and/or shutdowns in decorative or drinking fountains. A concern was expressed that, at this level, there would be more risk of customer slips on unwashed floors. A 35% shortage would require restroom closures and/or closure or hour restrictions of the mall restaurants. This would entail administrative and/or legal difficulties. If legally possible, this would, the respondent believes, lead to a loss of customers over time, with most revenue impacts on the mall restaurants.

Medical Offices

Three medical offices (including one dentist) responded to the survey; one large medical office was interviewed. To achieve a 15% reduction, outdoor watering cutbacks were cited by all three. One also cited outdoor surface washing. At 25%, one respondent suggested imposing restrictions on employee kitchens, lounges, and restrooms. No further actions were cited for a 35% shortage. The respondent from the large medical office said that at the 35% and even the 25% level, the

only alternative would be to close offices since reductions in indoor usage, comprised primarily of restroom and other sanitary uses, would be untenable.

Parks

Three county parks responded to the survey; no interviews were conducted. Not unexpectedly, at all shortage levels the action cited was to reduce landscape irrigation. Reducing outdoor surface washing (e.g. of tennis courts) and reduced vehicle washing were also cited.

"Green Industry"

"Green industry" survey and interview respondents included two retail plant nurseries, two landscape contractors, and one irrigation equipment supplier. The impacts on these businesses are unique in that their sales are affected not only by their own water usage, but by the water use cutbacks of their customers (primarily residences). Only nurseries use significant amount of water in their business, which is almost all for watering of their inventory. At all shortage levels, the major actions taken by nurseries would therefore be to reduce watering of this plant material and reduce the amount and/or change the type of inventory.

The hardships imposed on the industry by residential watering reductions will be discussed below.

Restaurants

In general, the four local restaurant industry representatives who were interviewed believe that they have already undertaken actions that have resulted in substantial water conservation. Their pursuit of water efficiency has been driven in large part by high sewer costs. They believe that these actions have "hardened" their demand to such an extent that there is not much more they could do to respond to a shortage, other than reducing their hours and/or days open or closing portions of the restaurant. They also pointed to the limitations that state health regulations place on water use reductions for such end uses as hand washing, dishwashing, general cleaning, and restrooms.

The eight survey responses tended to support these responses. Even at the 15% shortage level, several respondents indicated service reductions. Other possible actions included increased employee monitoring, decreased outdoor watering, more recycling, using more disposable dinnerware, and serving water only upon customer request. At a 25% level, there was more mention of service reductions, with two of the respondents indicating they would go out of business. A 35% shortage elicited an additional "going out of business" response.

Retailers

This is a very diverse category. The eight survey respondents included two bakeries, two car washes, two laundromats/dry cleaners, one auto dealership, and one service station. None of these respondents was interviewed.

Not surprisingly, the anticipated actions to respond to water shortages also varied. At the 15% level, only a few mentioned landscape watering, reflecting the insignificance of outdoor use for most of these businesses. A few mentioned closing restrooms to customers. There were also a few references to new investments in water-saving equipment, such as dishwashers, towel washing machines, or increased re-use. At 25%, there was one mention of curtailing hours, as well as some additional capital investments, while at 35%, three of the eight businesses indicated they would shut down, and a fourth expected reduced hours.

One of the laundromats pointed out that demand for their service will be greatly affected by residential water shortages. If residential customers' water usage is reduced through rationing or some other means, some will choose to bring their laundry to a laundromat. This respondent also argued that, moreover, the commercial washers in a laundromat are more efficient that home washers. Thus, a drought is precisely the time when "a laundromat is most useful to the city and

Schools

Four schools responded to our survey. Representatives of the Santa Cruz and Live Oak school districts were interviewed. For schools, the vast majority of water use is for irrigation of athletic fields and other landscaping. The fields are used by physical education classes and school teams, as well as by a variety of community groups, such as youth soccer and baseball leagues, adult soccer leagues, girls athletic league softball, etc.

Thus, the primary actions cited for all schools were reduction of outdoor watering and the field usage restrictions that would accompany those reductions. At a 15% shortage level, the impacts of the required reductions are expected to be minimal, with perhaps some usage restrictions by physical education classes and/or community groups. The usage restrictions would increase significantly during a 25% or 35% shortage. Interview respondents indicated that a 35% shortage would require a complete ban on field usage by community groups. A 35% shortage would also probably trigger retrofit of those irrigation fixtures that have not already been replaced.

As has been pointed out in other commercial/industrial sectors, water-saving actions by schools are limited by state regulation. State physical education requirements could limit the degree to which student field usage could be cut back in April, May, September, and October. State health codes limit reductions in other end uses, such as food preparation.

Santa Cruz Boardwalk

The Santa Cruz Boardwalk attracts 3.1 million visitors annually. The Boardwalk has already implemented a number of water conservation measures as a result of previous droughts. All public restrooms have been retrofitted with efficient fixtures, and water-cooled equipment has been precluded unless absolutely necessary. The Boardwalk also recycles water from water-cooled compressors for landscape use. There is also a fairly-refined system of metering and tracking individual end uses. The Boardwalk representative also pointed out that the Boardwalk has more flexibility than other businesses might in the sense that their business is diverse. For example, the number of food concession stands could be reduced and tourists could still be provided with "the boardwalk experience."

A 15% shortage would cause the Boardwalk to turn off the showers and reduce landscape watering. At the 25% level, management would intensify employee awareness and monitoring, and reduce pressures to some areas. Some restrooms might have to be closed. Neither of these would be expected to reduce business significantly. A 35% shortage would result in a total restroom closure and a closure of some food stands. Cleaning and landscape watering would be discontinued. This would mean some loss of income.

Other

Businesses that could not be placed in another category were placed here. They include a beauty college, two churches, a health club, a hot tub/massage spa, a swim complex, a jail, and a warehouse. The diversity of anticipated water-savings actions reflects the diversity of businesses. Thus, it is difficult to generalize about actions taken. The hardships on these "other" businesses will be discussed below.

HARDSHIPS IMPOSED BY CUTBACKS

While the literature has little to say about specific shortage-response actions by CI customers, it does address to some extent the hardships that past California droughts have imposed. This section begins with a summary of those findings, which is followed by a discussion of the hardships reported by Santa Cruz survey and interview respondents.

Evidence From Past California Droughts

Following are highlights of the reported impacts of prior droughts on California businesses:

- Commercial and industrial users tend to view water as an economic input to daily production and operations. Water supply availability directly affects the bottom line. Thus, business customers will tend to implement the most cost-effective conservation measures first, and only implement further conservation if the cost of the conservation is less than the expected lost revenue if the measure is not implemented.

Water supply cutbacks may affect these firms' employees and customers, as well as the overall economic well-being of the community.

- Surveys conducted during and after the 1976-77 California drought showed a high likelihood of business customers reporting very limited or no ability to save water in subsequent droughts without significant impacts on employment and income.[26] However, during the 1987-92 drought, businesses did, in fact, reduce water use substantially without significant economic impacts. Following that drought, customers again reported little ability to further reduce water use. [27] Just as is the case for residential customers, it is very difficult for most business customers to project how they would reduce water use until the need actually arises.

- Southern California commercial and service firms participating in a 1992 survey indicated, on average, they could absorb a maximum reduction equal to 17 percent from then-current consumption levels before significant effects to production and employment levels would set in.[28] When this is combined with prior studies that found that deliveries to the commercial sector in Southern California declined by about 11 percent between 1987 and 1991, this suggests a maximum reduction of about 28 percent from "normal" pre-drought consumption levels before these firms anticipate significant effects on production and employment levels.

- This study also found that half of the responding firms had altered expansion plans or considered relocating because of concerns about water supply reliability. Over 80 percent of the respondents indicated that the 1987-92 drought influenced their operations to some extent. All respondents indicated that the drought and associated water rationing had induced them to undertake some form of water conservation, and that rationing negatively affected their profits.

- A 1991 survey of 238 manufacturers in 22 industries found frequent or persistent water shortages could result in potentially significant impacts to output and employment in many of California's key industrial sectors[29]. On average, 23 percent of the surveyed firms indicated they would reduce output in response to a 15 percent water shortage. This grew to 36 percent when the shortage scenario increased to 30 percent.[30]

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[26] California Department of Water Resources, "Commercial and Industrial Drought Impact/Water Use Survey: 1977. December 1980.

[27] Wade, W., J. Hewitt, and M. Nussbaum, "Cost of Industrial Water Shortages," Spectrum Economics, Inc., prepared for California Urban Water Agencies. 1991.

[28] Foster Economics, Inc., "Water Use, Conservation, and Planning in the Commercial, Service, and Tourism Sectors of Southern California." January 1993.

[29] Wade et al, op. cit.

[30] It is important to note that these estimates are derived from survey responses to a hypothetical shortage. They are not empirically observed responses to an actual curtailment. It is very possible that actual responses would deviate from hypothetical responses.

- The 1987-92 drought had a major adverse affect on the state's green industry. A 1991 study showed a statewide loss of 4,500 jobs and $78 million in wages that could be attributed to 1991 shortages.[31]

Santa Cruz Survey and Interview Results

The foregoing findings must be supplemented by the Santa Cruz survey and interview results. Those results are divided into economic and non-economic hardships.

Economic Hardships

Most respondents indicated that an initial response to water shortage would be reductions in outdoor watering. It is likely that replacement of damaged landscape materials would impose an economic burden of unknown size on these customers.

For purposes of this discussion, the key measure chosen to summarize the economic hardship imposed on CI customers is the percent reduction in gross annual revenue.

These percent reductions are displayed in Table 7. Specifically, the table shows the average estimated percentage revenue reduction for those respondents who actually provided an estimate. Some respondents were unwilling or unable to provide an estimate; these blank responses are not counted. For the public sector customers (i.e. parks and schools), losses are, for the most part, non-economic.

For those sectors in which meaningful responses were provided, anticipated revenue losses increase as the shortage magnitude increases. Moreover, the anticipated revenue losses for some sectors are reported to be quite large, up to 50% for restaurants and 70% for retailers. The single large semiconductor manufacturer reported revenue losses ranging from 4% ($17.5 million) for a 15% shortage to 24% ($97.5 million).

One must be careful in interpreting these figures. They are self-reported estimates from a small number of customers who chose to respond to the questions on revenue losses. Some sectors are so heterogeneous that the small number of respondents could not possibly represent the sector as a whole. Thus, for retailers, responses were received from a bakery, two car washes and a laundromat. Responses to these questions from "other" business customers were from a health club, a hot tub-massage spa, a swim complex, and a warehouse.

Nevertheless, the figures are large enough to merit some concern. They are also at least roughly consistent with the findings in the literature review, which found that significant production

[31] Illingworth, Wendy, "The Effects of Water Shortage on California's Green Industry," Proceedings of the American Water Works Association's Annual Conference. 1994.

Table 7
Average Percent Gross Revenue Loss by Type of Business [1]

Business Type:	Number of Responses[2]	15% Shortage	25% Shortage	35% Shortage
Hospital	2	0.0%	NR[3]	NR
Hotel/Motel	1	0.1%	4.6%	NR
Office Bldg - Large	0	NR	NR	NR
Office Bldg - Small	1	0.0%	0.0%	0.0%
Manufacturing	3	8.1%	19.8%	29.8%
Mall	0	NR	NR	NR
Medical Office	0	NR	NR	NR
Park	3	0.0%	0.0%	0.0%
Plant Nursery	2	13.0%	23.5%	36.5%
Restaurant	6	16.7%	41.6%	50.8%
Retail	4	6.2%	33.8%	70.0%
School	3	0.0%	0.0%	0.0%
Other	4	13.8%	24.0%	38.7%
TOTAL[4]	**29**	**7.9%**	**19.6%**	**31.4%**

1. Entries for each business type is the unweighted average percent loss across all businesses of that type that responded to this question.
2. Maximum number of responses at any shortage level.
3. NR indicates no response given.
4. Totals are unweighted averages across all businesses that responded to this question.

cutbacks for commercial and service firms would begin to occur at a shortage level between 25% and 30%.

But the figures in the table only tell part of the story. The interview responses and the open-ended comments by survey respondents must also be considered. In several instances, survey respondents who foresaw very severe economic consequences (e.g. business closure) simply did not provide a numerical estimate of revenue losses. Some expressed their anger and frustration that the City was even contemplating such shortages, commenting that a particular degree of curtailment would shut down their business. (No attempt was made to impute a revenue loss figure based on open-ended comments.)

Thus, for example, **hotel/motel** respondents as a group expressed real concern about being put out of business, particularly in the event of more severe shortages, but only one respondent chose to provide estimates of revenue losses associated with 15% and 25% shortages, and no estimates were provided for a 35% shortage. Interview participants noted that many smaller hotels have very narrow profit margins and may even operate at a loss in the off-season. Having to close even a few rooms during the summer months when occupancy is high and rates are higher could lead to some hotels going out of business.

Restaurant representatives mentioned the employment and tax base impacts of closures or operational reductions and pointed out that many restaurant employees are unskilled or entry-level labor. One of the larger restaurants in town called the next drought an "economic disaster."

The large **mall** indicated ""substantial" economic hardships in the event of a 35% shortage, but did not provide a numerical estimate of lost revenue.

The large **semiconductor manufacturer** indicated a high possibility of plant closure in the event of 35% -- and possibly 25% -- shortages.

As described above, **retail nurseries** will suffer because of their own water supply restrictions as well as the reductions in outdoor watering of their residential customers. Sales volume was expected to drop "considerably" in the face of a 25% business shortage. One nursery representative estimated that a 20-25% cutback in *residential* outdoor watering – which could occur in fairly mild system shortages -- will result in a 7-10% drop in sales. The **landscape suppliers and contractors** said that residential cutbacks of that magnitude would drive some small and mid-sized companies out of business. For residential outdoor cutbacks as large as 50% -- which could be experienced in moderate shortages -- interview participants generally agreed that the impacts would be "devastating" for the industry "across the board." Many businesses would close with consequent impacts on employment and ancillary services such as trucking.

Several respondents from different sectors pointed out the seasonal nature of the Santa Cruz economy, and the extreme dependence of many businesses on summer revenues.

While the survey and interviews did not specifically address the issue of impacts on different-sized businesses, some respondents expressed the belief that smaller businesses would be most vulnerable to water shortages. This makes some sense, since smaller businesses typically have

fewer financial reserves on which to fall back, face proportionately more fixed costs, and are less likely to have diversified their businesses to better withstand a water cutback.

In addition to the direct economic impacts on the businesses themselves, many respondents pointed to expected impacts on the overall economic health of the community, specifically the tax and employment bases of the City of Santa Cruz, the Port, the City of Capitola, Santa Cruz County, and the state. For example, area hotels and motels contribute about $3.1 million annually to the City through the transient occupancy tax. In addition, some businesses mentioned their employment of entry-level labor, and the associated skill development, and work-force acculturation that would be lost due to reduced hours and/or business closure.

Non-Economic Hardships

Table 8 shows the *type* of non-economic hardship reported by the survey respondents for each of the three levels of shortage. Table 9 shows the *degree* of non-economic hardship severity reported. Some interesting conclusions can be drawn:

First, the type of hardship reported appears remarkably stable as the shortage severity increases. In all cases, the reported shortages are divided about equally among health and safety impacts, aesthetic impacts, and inconveniences. This stability seems to apply to most of the business sectors and is due largely to the fact that most respondents indicated that each of the three types of hardship would occur with some degree of severity.

In contrast, the degree of hardship increases markedly with the shortage magnitude. For a 15% shortage, nearly two-thirds of hardships are described as having no, little, or some impact. In contrast, 60% of hardships due to a 25% shortage are expected to be considerable or extreme, while fully one-half of the hardships due to a 35% shortage are described as extreme. The degree of reported hardship varies considerably across business sectors.

Even more than is the case for economic hardships, the quantified results in Tables 3 and 4 fall far short of adequately describing the reported impacts on Santa Cruz business customers. The interviews and the responses to the open-ended survey questions can add to our understanding of the manner in which shortages may affect the different commercial sectors. Following is a sampling of the key observations made by respondents.

- At higher shortage levels, **hospitals** might have to reschedule emergency surgeries and **medical offices** might have to close. In addition, a fear was expressed that, if patients had to use medical facilities in other communities, continuity of care would be sacrificed. Some HMO patients would be unable to get care in other communities at all. The hardship on the elderly and Medicare patients would be particularly severe. Respondents generally believed that such impacts would jeopardize community health and safety. It is likely that hardships would extend beyond the SCWD service area, since some facilities serve the entire North County.

Table 8
Hardship Category by Type of Business

Business Type:		15% Shortage					25% Shortage					35% Shortage				
		H&S	Aesthetic	Incon.	Other	Total	H&S	Aesthetic	Incon.	Other	Total	H&S	Aesthetic	Incon.	Other	Total
Hospital	N=3	29%	43%	29%	0%	100%	33%	33%	33%	0%	100%	n/a	n/a	n/a	n/a	n/a
Hotel/Motel	N=3	29%	43%	29%	0%	100%	29%	43%	29%	0%	100%	33%	33%	33%	0%	100%
Office Bldg - Large	N=1	0%	50%	50%	0%	100%	33%	33%	33%	0%	100%	25%	25%	25%	25%	100%
Office Bldg - Small	N=1	100%	0%	0%	0%	100%	0%	0%	50%	50%	100%	0%	0%	50%	50%	100%
Manufacturing	N=3	10%	30%	30%	30%	100%	18%	27%	27%	27%	100%	14%	29%	29%	29%	100%
Mall	N=1	0%	50%	50%	0%	100%	33%	33%	33%	0%	100%	33%	33%	33%	0%	100%
Medical Office	N=3	29%	43%	29%	0%	100%	33%	33%	33%	0%	100%	25%	50%	25%	0%	100%
Park	N=3	29%	29%	43%	0%	100%	25%	38%	38%	0%	100%	33%	33%	33%	0%	100%
Plant Nursery	N=2	0%	50%	25%	25%	100%	0%	50%	25%	25%	100%	0%	40%	20%	40%	100%
Restaurant	N=8	30%	30%	30%	9%	100%	29%	29%	29%	14%	100%	30%	30%	30%	10%	100%
Retail	N=8	27%	32%	32%	9%	100%	26%	32%	32%	11%	100%	31%	31%	31%	8%	100%
School	N=4	25%	33%	33%	8%	100%	31%	31%	31%	8%	100%	31%	31%	31%	8%	100%
Other	N=9	36%	27%	32%	5%	100%	33%	29%	33%	5%	100%	33%	33%	33%	0%	100%
TOTAL	N=49	27%	33%	32%	8%	100%	27%	31%	31%	10%	100%	28%	32%	31%	10%	100%

Table 9
Degree of Hardship by Type of Business

Business Type:		15% Shortage						25% Shortage						35% Shortage					
		None	Little	Some	Cons.	Extreme	Total	None	Little	Some	Cons.	Extreme	Total	None	Little	Some	Cons.	Extreme	Total
Hospital	N=3	0%	29%	29%	0%	43%	100%	0%	0%	33%	33%	33%	100%	n/a	n/a	n/a	n/a	n/a	n/a
Hotel/Motel	N=3	0%	14%	29%	43%	14%	100%	0%	0%	14%	43%	43%	100%	0%	0%	0%	50%	50%	100%
Office Bldg - Large	N=1	33%	0%	67%	0%	0%	100%	0%	0%	67%	33%	0%	100%	0%	0%	50%	50%	0%	100%
Office Bldg - Small	N=1	0%	0%	0%	100%	0%	100%	0%	0%	100%	0%	0%	100%	0%	0%	100%	0%	0%	100%
Manufacturing	N=3	9%	18%	36%	9%	27%	100%	8%	17%	8%	42%	25%	100%	13%	13%	0%	13%	63%	100%
Mall	N=1	0%	0%	50%	50%	0%	100%	0%	0%	100%	0%	0%	100%	0%	0%	67%	33%	0%	100%
Medical Office	N=3	22%	0%	22%	44%	11%	100%	25%	0%	0%	25%	50%	100%	33%	0%	0%	33%	33%	100%
Park	N=3	30%	20%	50%	0%	0%	100%	11%	22%	33%	33%	0%	100%	0%	22%	22%	33%	22%	100%
Plant Nursery	N=2	20%	0%	60%	20%	0%	100%	20%	0%	40%	20%	20%	100%	17%	0%	17%	33%	33%	100%
Restaurant	N=8	0%	4%	52%	22%	22%	100%	0%	5%	19%	38%	38%	100%	0%	0%	5%	25%	70%	100%
Retail	N=8	8%	17%	21%	29%	25%	100%	10%	5%	19%	24%	43%	100%	7%	0%	14%	14%	64%	100%
School	N=4	8%	15%	62%	15%	0%	100%	0%	23%	23%	46%	8%	100%	0%	23%	23%	8%	46%	100%
Other	N=9	4%	9%	48%	26%	13%	100%	5%	5%	36%	32%	23%	100%	0%	0%	20%	13%	67%	100%
TOTAL	N=49	9%	12%	41%	22%	16%	100%	8%	8%	28%	33%	27%	100%	6%	6%	17%	23%	50%	100%

- **Hotels and motels** anticipate that higher shortages would drive some smaller businesses to close permanently. The impacts of such closures on business owners and employees go beyond economic losses.

- The large **semiconductor manufacturer** anticipates 10% layoffs (62 employees) in response to a 25% shortage and 20% layoffs (124 employees) due to a 35% shortage. Again, the economic losses to the firm must be supplemented by the personal impacts of these layoffs.

- A **bottled water manufacturer** fears difficulty in meeting federal regulations that apply to his business.

- **Restaurants** talk of "serious" job losses, even in small shortages.

- A **car wash** pointed to the potential loss to the community in terms of skill development and maturity of its primarily entry-level labor force.

- **School District** representatives are concerned about the impact on student physical education of curtailed usage of athletic fields. This would also have significant impacts on community groups. Concern was also expressed about compliance with state regulatory requirements for both student physical education and food preparation.

- A local **beauty college** is concerned about state regulations for sanitary procedures. This business owner also foresees closure in the event of a 25% shortage.

- The **Santa Cruz Boardwalk** anticipates extreme health & safety and aesthetic hardships associated with a 35% shortage. Among other concerns, the Boardwalk provides bathroom facilities for the general public and beachgoers. Closing them would, according to the Boardwalk representative, result in public health impacts.

- A **jail** is concerned about state health and other regulations governing operations. The jail has no control over the number of inmates incarcerated at the facility. It is concerned that cutbacks of 25% or 35% would not be achievable.

- A 25% shortage would cause a **public swim center** to be unable to open, eliminating recreation and health services for the community.

SUMMARY AND CONCLUSIONS

The actions and hardships described above for CI customers are all based on descriptions provided by members of the Santa Cruz business community. The survey and interview respondents were asked to predict actions and hardships associated with cutbacks of a particular magnitude during a single peak season (April through October). But it is not just the magnitude of the shortage that will affect the hardships that customers experience; it is also the frequency and persistence of such shortages. It stands to reason that frequent shortages of a particular magnitude will be more burdensome than a single such shortage. Moreover, two or more consecutive seasons in which cutbacks are required may multiply the impacts considerably, particularly on smaller businesses. While these frequency effects undoubtedly exist, their importance cannot be gauged.

Following are brief summaries of the likely hardships at the three CI shortage levels, as reported by the survey and interview respondents:

15% CI Shortage

A 15% cutback of CI supplies can be expected during a 20-25% system shortage. Economic impacts will vary, with many businesses expecting these impacts to be manageable. Most businesses could get by with few if any production or employment cutbacks. Revenue losses for most sectors are anticipated to be fairly small. A key exception is the large semiconductor manufacturer which, even at this level of shortage, reports large ($17.5 million) losses.

Another exception is the "green industry", which would be significantly affected due to residential curtailments associated with this level of system shortage. Restaurants also report more significant impacts at this level due largely to their prior conservation actions.

Non-economic hardships are generally small, with the possible exception of hospitals and medical offices, hotels and motels, and retail establishments.

25% CI Shortage

This level of CI cutback corresponds to a 30%-40% system shortage. Production cutbacks and revenue losses become more frequent and of larger magnitude, averaging about 20% across all sectors. Particularly hard-hit sectors include restaurants and retailers. Residential cutbacks at this level of shortage will be very damaging to retail nurseries and landscape contractors. Smaller hotels and motels may feel severe economic stress. The large semiconductor manufacturer faces some possibility of plant closure. Employee layoffs will become more common. City, county, and state tax revenues will be affected.

Non-economic hardships are much more significant, with 60% being described as "considerable" or "extreme." The level of care of medical patients will be affected. Some smaller businesses will curtail their operations or close entirely, perhaps permanently. There will be some loss of

employment. The use of community facilities, such as school athletic fields, will be curtailed. Some customers may have difficulty complying with state regulations that depend on water use. The appearance of landscaping around business establishments will be seriously affected.

35% CI Shortage

A CI shortage of this magnitude will only occur in the event of a critical 50% system shortage. Average revenue losses across all businesses are expected to exceed 30%. For restaurants and retailers, these revenue losses approach catastrophic levels. Business closures will be more common, with the largest City employer anticipating closure at this level. Landscape contractors, particularly new and/or small businesses, will be hit very hard. More hotels and motels will shut down permanently. Losses to the community's tax base are likely to be more significant.

Fully 50% of non-economic hardships are characterized as "extreme." Business closures and layoffs will affect more members of the community, with young entry-level employees more likely to be affected. Hospitals will limit activity to emergency cases only. Outpatient care will be reduced or eliminated with serious impacts on community health and safety. School athletic fields will likely be closed to community users. The general appearance of the City's business districts will suffer as all outdoor watering around businesses ceases.

V. LARGE LANDSCAPE AND GOLF COURSE SHORTAGE IMPACTS

CLASS PROFILE

The customers in both of these classes are characterized by high-volume irrigation uses that are separately-metered. SCWD currently has two golf courses and about 340 large landscape accounts. Golf course annual demand ranges from 100 to 120 million gallons, while large landscape annual demand is about 135 million gallons. Together, the demands of these classes account for about 6% of the system total. Since virtually all of this demand is for irrigation, more than 95% of it is concentrated in the peak season (April-October).

PRIORITY-BASED CLASS SHORTAGE ALLOCATION

Table 10 summarizes the allocation of system-wide peak-season shortages to the two classes. Recall that golf course customers are considered to be industrial customers for both billing and shortage allocation purposes.

TABLE 10
PRIORITY-BASED SHORTAGE ALLOCATIONS TO LARGE LANDSCAPE AND GOLF COURSE CUSTOMERS

SHORTAGE CONDITION	SYSTEM SHORTFALL	LARGE LANDSCAPE SHORTAGE	GOLF COURSE SHORTAGE
Mild	10%	30%	5%
Moderate	20%	50%	15%
Serious	30%	60%	25%
Severe	40%	75%	30%
Critical	50%	100%	35%
Extreme	60%	100%	50%

LIKELY ACTIONS AND EXPECTED HARDSHIPS

Drought-related shortages affect large landscape and golf course customers somewhat differently than other customers. Since all class demands are outdoor, customers are likely to begin the peak season with a "deficit", since plant materials will have experienced less than normal rainfall during the winter. This may magnify the hardships associated with peak-season curtailments.

Another attribute shared by many of these customers is the value they offer to the community in terms of open space and potential recreational opportunities. This community value may be jeopardized in the event of a water shortage.

The discussion in this section is based on the results of a meeting with major SCWD large landscape and golf course customers. At the meeting, the following customers were represented:

- Lipton Company
- IOOF and Oakwood Cemeteries
- Pasatiempo Golf Club
- Homeless Garden Project
- Rodeo Gulch Homeowners Association
- North Bay Apartments

To better understand the actions and hardships that would result from future shortages, meeting participants were asked about hypothetical 25%, 50%, and 75% cutbacks. Following are the key actions and expected hardships discussed at the meeting. In most cases, it was impossible to reliably tie particular actions or hardships to specific shortage levels.

Lipton Company

As an economy move, the corporation has recently imposed water reduction goals on all its locations, including Santa Cruz. Thus, it is possible that the existing lawn area in front of the building will be replaced with less water-intensive material. Whether or not this happens, the impact on Lipton of a shortage of any size would be aesthetic, due to a deterioration of the appearance of the landscaped area around the building. In addition, there could be some economic impact because of a reduced need for contract landscapers and the cost of restoring the area after the shortage is over.

IOOF and Oakwood Cemeteries

These are the two largest memorial parks in Santa Cruz. Together, they comprise between 35 and 40 acres of primarily turf. Rather than uniformly reducing irrigation of the entire area in response to water shortage, cutbacks would be concentrated in the older sections of both cemeteries, since those receive fewer visitors. As the size of the shortage grows, the newer sections would be increasingly affected. Aside from the aesthetic impacts, the cemetery representative also cited emotional impacts on families and loved ones. A clear demonstration of these impacts is his being forced in the last drought to turn off the water at night to discourage families from bringing hoses to water their own sections.

In addition to the importance of the area to families and loved ones, the cemeteries provide open-space value to the community. In addition, historical tours are provided to students. Both of these benefits would be compromised in the event of significant water shortage.

The cemetery representative also expressed concern about the cost of restoring turf areas after the shortage.

Pasatiempo Golf Club

Pasatiempo is both a major recreational resource for the local community and a destination for a large number of out-of-town visitors. Annual revenues are around $6 million, and the course itself as well as the restaurant and pro shop employees many.

The course includes 80-85 acres of turf, divided into fairway, rough, tee, and green areas. Water use cutbacks would be allocated first to the roughs, which the club representatives estimate to be about 25-30% of total course area. Browning of these areas would least affect round quality. (Because of the higher turf in these areas, the water use per-acre is somewhat less than other portions of the course.)

The next areas affected would be the fairways, which comprise between 40% and 50% of the course. The highest priority areas are the tees and greens, which are essential for any use of the course. Moreover, the greens are extremely vulnerable to irrigation cutbacks.

In addition to the turf areas, there are a large number of trees, some of which were described as "irreplaceable."

The representatives estimated that a 25% water cutback would likely affect most or all of the rough areas and could begin to affect the fairways. A 50% cutback would affect all the roughs and a significant portion of the fairways. A shortage at or above this level was characterized as "devastating" in terms of quality of the experience, reduced visitation, and expense in restoring the course.

There are an estimated 50,000 rounds played annually at Pasatiempo, of which about half are played by local residents and half by guests from outside the community. While it is difficult to predict the impact of water shortage on these numbers, club representatives believe that a large number of the non-local rounds would be lost to other courses which are less affected by water shortage. A fear was expressed about a permanent loss of some of those out-of-town visitors. Local use would also be affected, although probably by a lesser amount.

This would have an economic impact on Pasatiempo shareholders, the restaurant and pro shop, and contractors. Employee layoffs would occur, as course maintenance would be reduced, and pro shop and restaurant usage would decline. There could also be an effect on the broader local economy, as fewer players visit the Santa Cruz area. A large expense associated with course recovery after the shortage is also likely.

Club representatives pointed out that, for economic reasons, Pasatiempo has made investments over the years to increase the efficiency of the irrigation system, including a weather station on site. They believe that this "hardening" of demand will intensify the impacts of future required cutbacks.

Homeless Garden Project

The current Homeless Garden Project site is located on Delaware Street and covers 3.5 acres. The garden is scheduled to move to a new location in about two years. The project grows primarily vegetables, which are then sold. The project employs and trains between 20 and 25 people at any one time. According to the project representative, the "primary crop" is their clients. The vegetable crop is essential to the clients' employment, training, and overall mental health. The current site is windy and has sandy soil, and is leased, thereby reducing the project's ability to invest to save water (e.g. by installing windbreaks). In spite of this, the project is converting to drip irrigation.

The project representative estimates that the project could carry on with as much as a 25% water cutback. Beyond this, the project would have to reduce the number of employees and the training that they receive. This would affect a clientele who are among the community's most vulnerable and could increase the burden on the local mental health system.

Rodeo Gulch Homeowners Association and North Bay Apartments

Rodeo Gulch includes 54 units, with landscaped area as well as a pool. The representative of the Rodeo Gulch Homeowners Association indicates that the complex faces some difficulty in reducing their landscape irrigation water use because of the landscape design and a faulty irrigation system. The complex is in the process of adjusting irrigation scheduling, replacing nozzles, and repairing system leaks. Through these activities, it is hoped that outdoor watering requirements will be reduced by 25%. In addition, future plantings will be drought-tolerant, and bare areas will be mulched this winter. Moreover, the bulk of the turf area is along a gulch and is rarely used. As a result, that area is no longer being watered.

The Rodeo Gulch representative indicated that complex managers would "scream" if asked to cut back significantly after they have taken all of these actions to reduce irrigation demand.

Interestingly, the complex does not currently have a pool cover. The representative indicated that a 50% cutback would cause them to purchase one. A 75% cutback would result in pool closure and would significantly affect landscape aesthetics in intensively-used areas such as entryways and the pool vicinity. The representative also anticipated that apartment values would decrease as the appearance of the complex deteriorates.

The North Bay representative indicated that a large portion of current outdoor water is applied to a large lawn area which is not used by residents. This area would be the first to be cut back in a shortage, resulting in purely aesthetic impacts. Other portions of the irrigation system would be selectively capped off. There would be more reliance on hand watering, which would be a more labor intensive form of irrigation, resulting in additional costs to the complex which might be passed through to tenants.

North Bay does not have a pool.

CONCLUSIONS

The priority-based allocation causes large landscape customers to experience the largest cutbacks of any customer class. Golf courses, as business customers, are spared the worst of the cutbacks. Because of the diversity of these customers, the hardships imposed by these cutbacks will vary considerably. Generally speaking, it is likely that customers like Lipton, for which the landscape is not an integral input to the product or service being offered, will not suffer unduly as a result of outdoor irrigation reductions.[32]

On the other hand, customers such as Pasatiempo, the cemeteries, and the Homeless Garden, for which a well-watered site is the essence of their business, could suffer substantial economic or non-economic hardships. Because of the priority-based allocation scheme, these customers will experience these large losses even during relatively moderate system-wide shortages. In the case of Pasatiempo, which is competing with golf courses throughout the region, the loss of visitors could linger well beyond the actual shortage event.

The hardships imposed on apartment complexes appear to fall somewhere between these extremes. There will certainly be aesthetic impacts, and perhaps some economic impacts. These hardships do not appear to be particularly severe.

As has been heard from other customer classes, some customers in these two classes have "hardened" their irrigation demands either in response to the last drought, or as an economic measure. This will magnify the hardships imposed by future shortages.

[32] This is not to say that such customers will not suffer from shortage-related cutbacks in their non-large-landscape accounts.

VI. UNIVERSITY OF CALIFORNIA SHORTAGE IMPACTS

CLASS PROFILE

UCSC annual demand for the 1999-2000 academic year was about 179 million gallons or 5% of the system total. Approximately 50% of the annual demand is associated with the housing and dining system, 35% with academic and administrative services, 3% each with the university arboretum and farm/garden, and 10% to athletics (primarily field watering).[33]

A distinguishing characteristic of the University is the manner in which demands are spread over the year. Unlike most other customers, for which summer demands are higher by far than demands in other months, UC demands are shaped in large part by the academic year. Between 1993 and 1997, the pattern of annual demands was "bi-modal," with the highest demands typically occurring in the October-November and April-June periods. UC demand during the system-wide peak-season (April-October) was approximately 63% of the UC annual total. As will be discussed below, it is expected that future summer utilization of the campus will increase, potentially modifying this historic water demand pattern. Approximately 30% of peak-season usage is outdoor.[34]

PRIORITY-BASED CLASS SHORTAGE ALLOCATION

Table 11 summarizes the allocation of system-wide peak-season shortages to the University.

TABLE 11
PRIORITY-BASED SHORTAGE ALLOCATIONS TO UCSC

SHORTAGE CONDITION	SYSTEM SHORTFALL	UCSC SHORTAGE	BASIS	
			INDOOR REDUCTION	OUTDOOR REDUCTION
Mild	**10%**	9%	0%	30%
Moderate	**20%**	20%	6%	50%
Serious	**30%**	28%	14%	60%
Severe	**40%**	37%	21%	75%
Critical	**50%**	49%	28%	100%
Extreme	**60%**	60%	42%	100%

[33] Estimated usage breakdown from Bob Dunn, UC Utilities Analyst

[34] Estimate based on historical data provided by Bob Dunn.

LIKELY ACTIONS AND EXPECTED HARDSHIPS

As was the case with the large landscape and golf course irrigation customers, the vehicle for gaining a better understanding of the UCSC actions and associated hardship was a meeting with representatives of different water-using segments of the University. The following University functions were represented:

- University Arboretum
- Summer programs and conferences
- Long Marine Laboratory
- University Farm/Garden
- Campus and Community Planning
- Housing, Dining, and Child Care Services
- Division of Natural Sciences
- Environmental Compliance Office

In addition, a Utilities Analyst from the University's Physical Plant office was present.

In general, meeting participants believed that University staff and students are much more conscious of water use efficiency than is the case for other parts of the SCWD service area. UC demands are therefore "hardened", which will make future drought responses more difficult. This is the case both behaviorally and in terms of low-flow fixtures, which were widely installed in the previous drought.

It was pointed out that, in addition to financial constraints, another potential disincentive to installing additional fixtures is a concern that the efficiencies that result from such installations will disadvantage the University when the next drought comes, since required cutback percentages will be much more difficult to achieve. (A similar concern was expressed by several of our commercial/industrial respondents.)

Specific shortage-response actions and hardships varied, of course, across the different University functions. Following are the key actions and expected hardships discussed at the meeting, by function. In most cases, it was impossible to reliably tie particular actions or hardships to specific shortage levels.

Summer programs

The campus hosts a variety of summer meetings, conferences, symposia, etc. which attract visitors from around the country. These events are an important educational resource and a major source of revenue to the campus. According to a July 5, 2000 article in the Santa Cruz Sentinel, as many as 15,000 conference visitors were expected this summer, generating $3.5 million for the university, which offsets a portion of student room and board fees. (It is likely that these visitors also contribute to the general economic health of the community, although this issue has

not been explicitly addressed.) These revenues also help pay for summer utilities, maintenance crews, etc.

As shortages become larger, UCSC representatives fear that some or all of these programs would have to be canceled.[35] Since contractual obligations for these programs are made well in advance of the point at which the existence or severity of summer water shortages are known, the university could be forced to renege on these obligations. This would encourage the summer programs to find other permanent locations, thereby depriving UCSC of the ongoing benefits of such programs. It would also result in considerable inconvenience and dislocation to conference organizers and participants, lost university revenues, and layoffs of custodial and other staff. Layoffs of staff during the summer months would reportedly be a "major problem" when the school year begins, with anticipated difficulties re-hiring laid off staff or recruiting new staff.

Moreover, summer use of the campus is increasing. The state legislature is considering a requirement for a summer academic quarter, and it is expected that, in the future, summer use of campus facilities will intensify. This will exacerbate the problems facing the University in the event of a summer water shortfall.

Residence Halls and Dining Facilities

There are currently about 175 residential buildings on campus housing more than 4,800 students. In 1989, in response to a City water conservation ordinance, the University housing staff did a comprehensive inventory and retrofit program throughout the residential buildings. At that time, all faucets were retrofitted with aerators, showers were converted to low-flow fixtures, flushometer toilets were replaced, and leaks were repaired. As a result, indoor use dropped significantly. More recently, all 174 clotheswashers on campus were replaced with high-efficiency units. Current per-capita indoor use remains more than 20% below pre-drought levels.

In the 1987-92 drought, usage curtailments were accomplished through a combination of hardware retrofits and behavioral changes. With almost all cost-effective conservation measures now in place,[36] usage curtailments in a future drought in the residential buildings will depend on student behavioral modifications. The substantial ongoing resident education programs would be intensified. Since most buildings are individually-metered, monitoring and reporting activities would increase. Fixture replacement would be accelerated as available funds permit.

In the five dining halls, water-cooled refrigeration equipment was replaced with air-cooled devices between 1989 and 1992 as a mitigation measure for the University's long-range development plan. In a future drought, the dining halls would move to use of paper and plastic utensils.

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[35] To some extent, summer programs will be affected by most or all of the water-saving actions to be taken by the various university sectors.

[36] Most old dormitories still have 3.5 gpf flushometer toilets and some apartments still have older toilets.

Natural Sciences

Most water in this university division is used in instructional and research laboratories. In addition to sanitary uses, major current water uses include:

- Plant watering for research and instructional use in greenhouses
- Making solutions, mixing media
- Glassware washing
- Rock cutting
- Cleaning counters, wiping down equipment
- Ice making
- Flushing filters on building reverse osmosis water system

Key current conservation measures include:

- Washing and rinsing glassware in tubs
- Running full loads in glassware washers
- Using disposable glass and plasticware where practical
- Installation of spring-loaded water taps in many laboratory areas
- Use of recirculating equipment cooling systems
- Water conservation education of new students and employees

Potential additional identified conservation measures include:

- Additional education
- Shorter duration glassware rinsing, more tub rinsing
- Use of more disposable glass and plastic
- Verification of minimum settings on glassware washers

The representative of this division believes that even a 15% reduction in water usage in instructional laboratories would result in classes being eliminated. This would affect the core laboratory classes, which could have far-reaching effects on entire programs, and potentially delay student graduation. This, in turn, would increase student costs and affect UCSC's ability to attract better students. In addition, the natural science division's summer programs for high school and college students would be adversely affected, especially outreach programs to K-12 students.

In research laboratories, it is believed that any reductions exceeding 5-10% "would have a profound effect upon research activities, curtailing research production, and causing a ripple or domino effect that would seriously challenge the university's ability to sustain vibrant research

activities."[37] One impact of this would be a diminution of grants to the university, which are integral to the university's operation.

Arboretum

The University Arboretum accounts for approximately 3% of UC's total annual water usage. The plantings in the arboretum are generally not water-intensive (i.e. there are no lawn areas); much of the material is drought-resistant. Arboretum representatives indicated that the first action they would take would be to fix leaks and cut back on overhead sprinklers, moving instead to drip irrigation or hand watering.[38] More severe cutbacks would result in a reduction in nursery production, and an attempt to confine watering to those plants which are least tolerant to drought, including young plants whose root systems are not well established. As a last resort, certain plants (presumably the less valuable ones) would be allowed to die, which was described as "catastrophic" for the arboretum.

It was pointed out that multi-year shortages, such as occurred in previous droughts, would multiply the impacts on plantings.

The arboretum representative indicated that the arboretum is a result of 35 years of effort. Some plants are irreplaceable if they die as a result of a water shortage. While these most valuable plants would receive the highest priority for irrigation, there is still a concern that, particularly in severe and/or prolonged shortages, some would be lost.

University Farm/Garden

The farm/garden is a 25-acre site of which 12 acres are planted. It is unique in that revenue-producing crops are grown. A portion of the revenues goes to pay salaries of farm/garden personnel. Current water usage is low, in the 1 acre-foot per acre range. The farm/garden manager reports that 80% of irrigation volume is delivered through drip tape; there is also some dry farming. Only pre-irrigation is by sprinkler. The manager believes that anything up to a 20% shortage would be dealt with through cutbacks in ornamentals, etc. Anything above that would result in revenue losses, staffing reductions, and an impact on the educational program.

Long Marine Laboratory

This facility, located at Terrace Point is physically separated from the main UCSC campus. The laboratory representative stated that, as a result of fixture replacements during the previous drought, lab demands have "hardened." Anticipated actions, in order of shortage severity, include:

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[37] Kerrie McCaffrey. "Water Rationing for the Natural Sciences: Preliminary Discussion Notes." October 3, 2000

[38] Hand watering would be extremely labor-intensive, potentially resulting in added costs.

- Cutting back, and then ceasing, landscape irrigation. The laboratory representative indicated that the lab has already planted drought-tolerant vegetation at its site.

- Requesting voluntary cutbacks from lab personnel.

- Mandatory restrictions or bans on outdoor use in animal areas, equipment (e.g. boat) rinsing, etc.

- Finally, blackout periods accomplished by turning off certain valves at particular times of day.

As a result of these actions, the laboratory representative expects "some tremendous losses." Two examples were offered:

- The lab is in partnership with the state Department of Fish and Game to respond to infrequent (approximately one per year) oil spills. Water is needed to wash animals and for other purposes.

- The lab also houses facilities of the National Marine Fisheries Service. It is anticipated that NMFS will ultimately have some freshwater-dependent facilities. While these facilities, which represent major investments, will rely as much as possible on recirculated water, they will still have a need for constant new water supplies.

The representative observed that research projects at the lab "can't just be turned off." The potential exists for the loss of many years of research.

Finally, the lab is also a community resource, which is open to the public. The Seymour Marine Discovery Center currently receives 40,000-50,000 visitors annually. This figure is expected to grow over time to 75,000. The value of this resource could be diminished as a result of a water shortage.

Athletic Fields

While much of the campus vegetation is fairly drought-resistant, the athletic fields are not. The university's policy is that physical education as a critical part of students' social development. It is feared that a water shortage could reduce the usability of the fields and thereby compromise this policy. The campus is currently installing a centrally-controlled computer system for irrigating fields. This is expected to achieve significant conservation, although "probably not 25%."

CONCLUSIONS

Generally speaking, all university functions believed their missions would be seriously affected by water shortage. Due in part to the perceived base efficiency of UC water use, some university sectors project serious impacts even with relatively small shortages. Other sectors believe they could withstand these small shortages without suffering undue damage.

The primary mission of the university, of course, is education. A large number of meeting participants felt that the university's educational objectives could be compromised by water shortages. The extent to which this will occur is a function of shortage size, duration, and frequency.

VII. MUNICIPAL WATER SHORTAGE IMPACTS

The final customer class for which shortage impacts were investigated was the Municipal class, which includes all demands of City of Santa Cruz departments and agencies.

CLASS DEMAND PROFILE

Annual municipal demand is estimated at just over 50 million gallons, about 1% of total system demand. The vast majority of municipal demand is for irrigation of City-owned facilities, including parks, fields, and the municipal golf course. Thus, about 80% of this demand is concentrated in the peak-season.

PRIORITY-BASED CLASS SHORTAGE ALLOCATION

Table 12 summarizes the allocation of system-wide peak-season shortages to municipal demands. Note that all municipal demands are considered to have a "business" usage priority.

TABLE 12
PRIORITY-BASED SHORTAGE ALLOCATIONS TO MUNICIPAL DEMANDS

SHORTAGE CONDITION	SYSTEM SHORTFALL	MUNICIPAL SHORTAGE
Mild	10%	5%
Moderate	20%	15%
Serious	30%	25%
Severe	40%	30%
Critical	50%	35%
Extreme	60%	50%

MUNICIPAL SHORTAGE IMPACTS

The assessment of municipal shortage impacts was based on a meeting with City department representatives. Departments and functions represented included:

Public Works Department

- Operations
- Wastewater treatment
- Sewage collection

Parks and Recreation Department

- Director's office
- Golf course

Water Department

City Manager's Office

Finance Department

Following is a discussion of shortage impacts on the three operating departments and on City finances.

Public Works Department

Public Works Department representatives discussed water shortage impacts in several areas. Each will be discussed in turn.

Landfill/Resource Recovery Center

At the landfill, water use is primarily for dust control, which is required by the landfill's permit. This is partly for aesthetic reasons, and partly out of considerations for neighboring residences. This use would be reduced in a shortage. There is also a minimal level of irrigation of plant material at the landfill. New plantings would be suspended and irrigation would be reduced or eliminated entirely.

The solid waste collection function would also be affected by a water shortage. Street sweepers use significant amounts of water and, although the Department is moving toward technologies that are more water efficient, this activity would be cut back in the event of a shortage. Street spills would have to be taken care of. Paradoxically, as other water customers move to disposable (e.g. paper and plastic) products to reduce their water use, the need for street sweeping activities could increase.

Corporation Yard

The washing of garbage trucks, which is currently performed every other day, would be one of the first uses to be cut back in a water shortage. Water-use in saw-cutting of streets would also be reduced, resulting in more dust.

Wastewater and Stormwater Collection

In the previous drought, there was an increased problem of clogged sewer lines, because of reduced flushing and/or use of low-flush toilets, which have a much smaller "drain line carry" distance. Similar problems could be anticipated in a future shortage. Addressing these problems could require increased water use.

One item that would not be cut back is cleaning of storm drains, which is not a large water user.

Wastewater Treatment

A committee is currently looking for ways to reduce water use at the treatment plant as part of an overall effort to cut operating costs. However, the plant has already saved a large amount through internal recycling. Additional significant cutbacks would therefore be very difficult. Although it uses a relatively small amount of water, landscape irrigation around the plant would be discontinued, thereby reducing the aesthetic benefits of this greenery.

In general, Department representatives indicated that water demand in many areas has already been considerably "hardened". Moreover, many of the Department's functions are subject to federal and state regulation and potential fines if activity levels fall too low. These factors significantly reduce water-use flexibility.

Parks and Recreation Department

Municipal Golf Course

Many of the anticipated impacts at the municipal course are similar to those reported by Pasatiempo course representatives. Cutbacks would first affect rough areas, followed by fairways, and then greens and tees. It is estimated that a 50% cutback would significantly affect rough and fairway areas, and eliminate equipment washing. (In the previous drought, fairways were allowed to go brown.) In addition, there would be a loss of some of the younger trees.

A major concern is the City's Integrated Pest Management (IPM) policy. It is feared that, if turf areas were allowed to die, there could be a massive invasion of weeds. Without the use of herbicides, a large amount of labor and a multi-year period would be required to bring the course back to its present condition. The financial costs of this effort would also be substantial. It is estimated that the seed alone would cost around $40,000. Moreover, Department representatives estimate that a 50% cutback in irrigation water would mean a 70% cut in rounds played, which equates to about a $700,000 annual revenue loss.

Parks

Department representatives estimate that a 25% cutback would alter maintenance practices and generally reduce irrigation. There would be an attempt to maintain street trees and direct some water to the major park areas. There would a dramatic cutback in irrigation of neighborhood parks. Showers at pools would be closed. A 50% cutback would be "catastrophic." Pools would likely be closed. Recreation programs would likely have to be cancelled. Staffing reductions would be significant.

As is the case at the golf course, the City's IPM policy would greatly increase the costs and lengthen the time to bring back park areas after the shortage is over.

Other Park and Recreation Department Functions

Other impacts on the Park and Recreation Department include:

- Street washing would be one of the first functions eliminated due to water shortage.
- Additional patrolling would be needed in open-space areas to reduce the likelihood of wildfires.
- Loss of river levee landscaping could impose large costs on the Department.

Water Department

The effects of a shortage on the Water Department itself would be felt in several areas.

Administration

- There would be substantial time required to manage and respond to the shortage.
- An appeals board would have to be convened and staffed.
- There would be potential impacts on revenues and rates.
- There would be media and public relations issues to manage.

Customer Service

- Customer service representatives would have to deal on a day-to-day basis with public concerns.
- There would be increased effort to explain the billing system, usage restrictions, and rationing rules.

- Duties for field personnel would increase.
- There would be an increase in data management and reporting.
- More frequent meter reading would be required.

Conservation

- The Department's conservation staff would have to mobilize a "drought patrol" to enforce water waste rules and would also have to deal with correspondence regarding those issues.
- There would be a stepped-up level of public education, information, and outreach.
- There would be a redirection of effort away from the Department's long-term conservation programs, which are a key part of the Integrated Water Plan.
- Increased customer contact would be required to resolve problems, complaints, billing adjustments.
- There would be ongoing contact with individual businesses, large landscape customers, and sites having problems meeting goals.

Distribution

- Additional labor would be required to fix leaks. This could include increased use of contractors.
- There would be a cessation of main flushing.

Financial Impacts

A prolonged water shortage would have an adverse affect on several City revenue sources, including the sales tax, water revenues, non-residential wastewater revenues, golf course revenues, and utility tax revenues. As discussed above, the City could also incur significant costs in restoring plant materials to their pre-shortage conditions.

VIII. SUMMARY AND CONCLUSIONS

SUMMARY OF SHORTAGE IMPACTS

This report has discussed a wide variety of shortage impacts for each class of SCWD customers. The nature of these impacts and their diversity provides a rich source of information to the City as it makes its water resource decisions. At the same time, this variety provides an analytical and policymaking challenge. Table 13 represents an attempt to summarize and supplement the detailed class-specific shortage impact information presented in preceding sections. The table rates the overall shortage impacts for each class[39] on a 6-point scale, ranging from "little or no" impact through "catastrophic" impact.

These ratings are relative within each class and are necessarily somewhat subjective. They are intended to enable quick comparisons within each class of service of the impacts of different shortage sizes. Although the scale is useful for comparisons within classes, it is much more problematic to make direct comparisons across classes. Thus, a rating of "3" for residential customers is not equivalent to the same rating for business customers.

What can be compared across classes are the rates at which the impacts increase as the system-wide shortage grows. Thus, despite the fact that business and industrial customers experience smaller percentage cutbacks than do residential customers at each level of system shortage, the impacts on these non-residential customers increase more quickly than do the residential impacts. Thus, for example, a moderate 20% overall system shortage would result in residential shortages of about 20%, while business, industrial, and golf course customers would be subjected to about 15% cutbacks. However, according to the non-residential respondents, the impacts of this moderate shortage level are already beginning to grow, particularly for industrial customers.

Similarly a 30% system shortage is reported to affect industrial customers in major ways, whereas residential customers will experience important, but not as serious impacts.

It bears repeating that the highly-summarized results of Table 13 are not a substitute for the descriptive material in the rest of the report. Instead, they represent an alternative "entry-point" for policymakers into the richer information.

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[39] Only those classes for which it is possible to meaningfully differentiate among different shortage magnitudes are shown.

SHORTAGE IMPACTS IN THE INTEGRATED WATER PLAN

As described above, the City of Santa Cruz, in its Integrated Water Plan, will have to determine the appropriate combination of new supplies, enhanced water conservation programming, and future shortages. To inform these choices, this study is intended to provide decision-makers an understanding of the types and magnitudes of hardships that different customer classes will face in the event of various magnitudes of future water shortages.

The City will ultimately have to decide which supplies it wants to develop (and in what sequence and with what timing), with which conservation programs it wants to proceed (and with what level of intensity), and what frequency and magnitude of water shortages it is willing to tolerate. This decision requires that tradeoffs be made among the costs and benefits of these three components. These tradeoffs will be driven by quantitative as well as qualitative information. Information that cannot be quantified is not any less important.

City policymakers must determine what future strategy is best for the community, its residents, and its businesses. This is partly a matter of numbers. For instance, all else being equal, the community is better off if costs and therefore water rates are kept down. But numbers tell only part of the story. For example, to the extent that one resource is anticipated to have greater environmental impacts, that resource may be viewed with less favor even though it is less expensive. To the extent that community values favor one type of water resource over another, that will weigh in that resource's favor, despite the fact that it may be more costly.

Thus, while the customer shortage impacts discussed in this report are generally not expressed numerically, they are critical to the City's decision-making process. The IWP will be forecasting the future water supply reliability associated with particular resource strategies. The reliability is a function of such parameters as the supply characteristics of existing and new supplies, the capacity constraints of transmission and treatment facilities, water rights and instream flow constraints, future demands, conservation savings, etc. While reliability can be expressed in a variety of ways, the key descriptors are the expected frequency and magnitude of future water shortages. Policymakers will be asked to choose among strategy alternatives that have different costs, supply reliabilities, and other characteristics.

The results of this study are designed to enable policymakers to associate different shortage magnitudes with the hardships that these shortages impose on customers. This allows the form of the key tradeoff questions to change. Instead of asking "Should the City spend so many dollars to reduce the expected frequency of an x% shortage by a specified amount?," policymakers will be able to ask whether the City should spend those dollars to reduce the expected frequency of a particular set of customer hardships. Instead of focusing on the size of the shortage, the focus is shifted to impacts on customers, which is where it should be.

Table 13

ESTIMATED RELATIVE CUSTOMER CLASS PEAK-SEASON SHORTAGE IMPACTS

SHORTAGE CONDITION	PEAK-SEASON SYSTEM SHORTAGE	SINGLE-FAMILY		MULTI-FAMILY		BUSINESS		INDUSTRIAL		GOLF	
		SHORTAGE	IMPACT	SHORTAGE	IMPACT	SHORTAGE	IMPACT	SHORTAGE	IMPACT	SHORTAGE	IMPACT
Mild	10%	11%	1	9%	1	4%	1	5%	2	5%	1
Moderate	20%	22%	1	19%	1	13%	2	15%	3	15%	2-3
Serious	30%	31%	3	27%	3	22%	4	25%	5	25%	4
Severe	40%	41%	4	37%	4	27%	4-5	30%	5	30%	4-5
Critical	50%	54%	5-6	48%	5-6	33%	6	35%	6	35%	5
Extreme	60%	63%	6	56%	6	48%	6	50%	6	50%	6

Key to Shortage Impacts:

1. Little or none
2. Some
3. Intermediate
4. Considerable
5. Major
6. Catastrophic

APPENDICES

APPENDIX A

LITERATURE REVIEW

- To minimize concerns about fairness and equity, water allotments should be based upon the number of people served, not previous year's use, size of lot, square feet in the house or any other similar criteria. Customers often view allocations based on past use as rewarding water wasters and punishing those investing in conservation early on. Similarly, allocations based on lot size or home square footage are frequently viewed as economically regressive. Nonetheless, it is important to point out that water agencies frequently have found it difficult to follow this prescription. Particularly, in the 1987-92 drought, agencies became embroiled in debates about how to fairly allocate a rationed supply. These debates often pitted one user group against another (e.g., outlying suburban customers with large lots and extensive landscaping against customers in denser urban areas). Worse, from the perspective of the utility, these debates frequently shifted into the political arena. It is fair to say that, no matter what allocation policy an agency adopts, it is likely to encounter at least one customer group that finds it objectionable.

- Rationing programs for acute shortages should be mandatory, even if restrictions and penalties are not severe. Consumer ratings for program effectiveness and fairness point to the need for making programs mandatory. Mandatory programs appear to reduce concerns about free-riders, reinforce agency messages about the need to conserve, and foster group awareness and identity (i.e., one for all and all for one, because the utility says we have to).

- Consumer evaluations for the three rigorous conservation programs were remarkably nonnegative for overall performance, fairness, and effectiveness. Results indicate that stringent residential water conservation programs can be instituted which consumers judge to be both equitable and effective. Consumer resistance or negativity towards conservation does not necessarily increase with the stringency of an agency's conservation potential. Bruvold's survey research found that mild programs elicited more concerns about fairness and effectiveness than did rigorous programs.

- To the extent that a program employs rules and prohibitions, these should be enforceable, and in fact enforced. Lack of enforcement or inconsistent enforcement was found to lower customer morale, send double messages about the need to conserve, and generally reduce the effectiveness of the program.

- Clear and consistent communication between a water district and its residential customers is essential. Information on the water situation and on rationing programs needs to be communicated as clearly, simply, accurately, and consistently as possible. Frequent feedback appears to increase program effectiveness, as do clearly stated goals.

- Bruvold (1979) concluded that those strongly believing in the need for long-term conservation were the most likely to reduce actual daily water use during a shortage. While those perceiving a short-term crisis were more likely to adopt new

> conservation measures, such adoption did not correlate with reductions in per capita daily use figures. According to Bruvold, the best and most effective approach to reduced residential use may come from steady, long-range, methodical programs carried out in a non-emergency atmosphere.

Berk et al. concluded that more programs are better than less. Programs did not exhibit declining marginal returns. That is, adding more programs did not appear to affect the ability of existing programs to tap into the pool of potential water savings.

Water Rates: A Two-Edged Sword

Berk, et al. (1981) concluded that pricing policy and conservation programs tend to be complimentary rather than competitive ways of reducing residential water use. That is, one reinforces the effectiveness of the other. Certainly, there is overwhelming evidence that pricing policy can be used effectively to curb water demand during periods of drought (Mitchell and Hanemann, 1994). During the 1987-92 drought, 80 percent of the largest urban water suppliers in California had increased rates or added rate surcharges to manage ongoing shortages (Dziegielewski, et al., 1993).

However, it should also be emphasized that drought pricing policies have proven the most likely cause for customer backlash and even legal challenges to a utility's conservation program. Many urban water suppliers during the 1987-92 drought, such as the Los Angeles Department of Water and Power, Eastern Municipal Water Agency, Las Virgenes MWD, and East Bay MUD, became embroiled in debates over drought pricing policies. In the absence of appropriate revenue reserve policies, agencies often found themselves in the difficult position of asking consumers to use less water and then having to charge more for it to offset revenue shortfalls. The Los Angeles Times, for example, ran the headline "No Good Deed Goes Unpunished" in response to LADWP's proposed rate hike (Dziegielewski, et al., 1993). In some instances, these debates resulted in legal challenges to the district's rates. Both EBMUD and Las Virgenes MWD, for example, were sued by customers objecting to the districts' rates (Mitchell and Hanemann, 1994). As with debates over allocation policy, the tendency for these debates to shift into the political arena is high. The double-bind water suppliers frequently encounter with rates during shortages is summarized by Dziegielewski, et al. (1993) as follows:[43]

> *Agencies with substantial revenue shortfalls caused by reduced water use as well as increased cost of operations during drought had to increase water rates. From the public's point of view, this was unfair. It seemed their reward for good behavior in conserving water was higher rates. Rate hikes meet strong public objections during periods without drought, and there is no reason to expect public support for rate increases during or shortly after a drought. The press was not supportive either and, as*

[43] Utilities may at least partially counter these concerns by making the distinction between rates and bills. Even though rates increase, bills of conserving customers may well decrease. This is not necessarily an easy sell, but it is often a point that gets lost in the political storm.

in most rate hikes, they were likely to blame the mismanagement of water utilities for cost increases. The outcome of this dilemma is undermined confidence of the public in their water agencies and possible reluctance to conserve water in the future.

Demand Hardening

More recently, water suppliers have begun to question whether demand reduction strategies for managing temporary shortages are viable over the long-run. The argument runs that with each shortage water users make changes to hardware, modify production processes, adjust behavior, and generally increase the efficiency of their water use. Thus, with each passing shortage, customers have fewer and fewer options for conserving water. In the water management literature this has been termed demand hardening, which is defined as the diminished ability or willingness of customers to reduce their demand for water during a shortage (Tabors Caramanis and Associates, 1994).

To the extent that long-term conservation measures involve the same practices or devices as short-term shortage management, the same water cannot be saved twice. For example, a region installing ultra-low-flow toilets would have less ability to conserve water used by toilets during droughts than a region with high-flow toilets. In the commercial and industrial sectors, businesses seeking to maximize profits implement the most cost effective conservation measures first and then undertake additional conservation projects up to the point at which the cost of the conservation project equals the net revenue it protects. Beyond this point, the cost of conservation exceeds its benefits, and firms lose less money by reducing output and employment than by undertaking additional conservation. Over time, as businesses improve water use efficiency the cost of making additional improvements may increase. In the economics literature this phenomenon is termed diminishing returns to production. But it can also be viewed as a form of demand hardening.

Counterbalancing these effects, however, are three considerations. First, technological advancement is expected to continue to increase input substitution possibilities and increase the elasticity of demand for water in some uses. Second, a region may reduce the frequency and severity of shortages, and hence the need to reduce demand during shortages, by investing in long-term conservation. Third, as described above, survey research suggests those making investments in long-term conservation (i.e., those most susceptible to demand hardening) also have the highest likelihood to reducing their demands during shortages (Bruvold, 1979).

Evidence of demand hardening is largely anecdotal. Our review of the literature did not identify any empirical studies quantifying the pervasiveness or magnitude of demand hardening effects. If anything, the literature suggests demand hardening is largely a hypothetical issue. For example, surveys conducted during and immediately following the 1976-77 drought found a high propensity among commercial and industrial firms to report very limited or no ability to make further reductions in their demands for water without causing significant impacts to employment and income (California Department of Water Resources, 1980). Yet during the 1987-92 drought, commercial and industrial firms substantially reduced water use without significant impacts to employment or income. As expected, surveys conducted during and immediately after this later

drought also found a high propensity among commercial and industrial firms to report very limited or no ability to make further reductions in their demands for water (Wade, et al., 1991). One rather suspects that should another serious drought occur in the near future, these sectors will again find ways to adjust production to accommodate the shortage.

The anecdotal evidence suggests that demand hardening is a manageable second-order effect (Wade, et al., 1991). The arguments supporting demand hardening as a first order effect are somewhat Malthusian. They tend to discount or ignore advances in technology, production input substitution, and behavioral changes in response to the rising cost or decreasing reliability of water supply.

The literature consists largely of discussions of the theory of demand hardening, engineering estimates of the effects of long-term conservation on the ability to conserve water during temporary shortages, and non-scientific survey results relying on self-reported information.

- In a 1992 report, Metropolitan Water District (MWD) estimated that investments in long-term conservation could potentially reduce Southern California's ability to manage temporary shortages using traditional methods (Foster Associates, 1992). It estimated that regional demands declined by 18 percent in 1991 through a combination of rationing, education, water appliance modification, and pricing strategies. By 2010, MWD estimated similar measures would produce only a 12 percent reduction because of the demand hardening effects of investments in long-term conservation. The report notes, however, that the combined reduction in 2010 demand due to long-term conservation and shortage management would be 25 percent (compared to 18 percent in 1991). The report concluded that if water saved from long-term conservation were used to increase system reliability, rather than to meet new demand, long-term conservation would increase the region's ability to manage shortages in the future. On the other hand, if water saved from long-term conservation were used to supply demand growth, the region's ability to respond to future temporary shortages would be diminished.

- Southern California commercial and service firms participating in a 1992 survey (Foster Associates, 1993) indicated, on average, they could absorb a maximum reduction equal to 17 percent over current consumption levels before significant effects to production and employment levels would set in. Given that the RAND study found deliveries to the commercial sector in Southern California declined by about 11 percent between 1987 and 1991, this suggests a maximum reduction of about 28 percent from 1986 consumption levels before these firms anticipate significant effects to production and employment levels. The majority of respondents indicated that additional investments in conservation would be increasingly costly to make. Some respondents indicated that additional conservation at their facility was not economically or technically feasible.

ECONOMIC EFFECTS OF DROUGHT MANAGEMENT POLICIES

Consumer drought impacts can be wide ranging and may include inconvenience, loss of assets (e.g., loss of landscape material), reduced employment, reduced income, and reduced economic activity.

The economics literature uses the concept of willingness-to-pay to value these types of impact. In the context of a water shortage, willingness-to-pay is defined as the maximum individuals would have been willing to pay to avoid the shortage management policies imposed by water agencies (Dixon, et al., 1996). This amount measures the change in economic welfare resulting from the shortage. Positive willingness-to-pay indicates the shortage reduced economic welfare for at least some individuals.

In the face of shortage management policies, consumers can adapt their behavior, modify consumption patterns, and invest in alternative technologies to offset to some extent these welfare losses. Thus, the extent of welfare loss depends to a large degree on whether water is an essential input to some highly valued activity, or whether there are ready substitutes for its use. This in turn implies that shortage management policies may unevenly distribute welfare losses across the population of water users. Some users will more easily adapt to shortages or value water less than others will.

Consumer impacts can be quite diffuse and accurate measurement of willingness-to-pay is difficult under the best circumstances. Several studies have employed various measurement methods to estimate consumer impacts of water shortages. Each of these studies has limitations in terms of comprehensiveness, reliability, and the ability to extrapolate results across time and space. Nonetheless, they indicate somewhat the type and distribution of welfare losses of water shortages as well as their likely magnitude.

The following briefly describes how alternative shortage management policies are likely to affect the economic welfare of end users. An end user is somebody that uses water for final consumption rather than as an input to the production of a good or service sold in the market.[44]

Type-of-Use Restrictions. Consumers whose water use is constrained by the restrictions are made worse off. Users observing the restrictions forgo the net benefits of some water uses. Violating the restrictions risks other potential economic consequences, such as monetary penalties. Consequently, affected consumers would be willing to pay some amount to avoid these restrictions. The magnitude of the willingness-to-pay to avoid type-of-use restrictions would depend on the type of restrictions, how often the user engaged in the restricted activity before the drought, the probability of being caught, and the penalty if caught.

Price Increases. Higher prices cause consumers to pay more for a given amount of water and to forgo the net benefit of water that is no longer consumed. To avoid these losses, consumers

[44] The discussion in this and the next section is adapted from Dixon, L., N. Moore and E. Pint, "Drought Management Policies and Economic Effects in Urban Areas of California, 1987-1992," RAND, 1996.

would be willing to pay the sum of the increased water costs plus the forgone net benefit of the reduced water use. In the economics literature this is referred to as lost consumer surplus, and can be measured using survey and/or demand curve analysis.

Consumers may be indirectly affected by increases in product prices caused by higher water costs. Some firms may be able to pass on higher water costs to the consumer or a reduction in production due to higher water costs may force product prices up. Consumer welfare would decrease as a result.

Quantity Restrictions. When quantity restrictions (e.g., rationing) are binding, the consumer loses the benefits of the forgone water use and would be willing to pay a positive amount to avoid the restriction. When deciding whether to observe quantity restrictions, consumers presumably weigh the forgone benefits of reduced consumption against the penalties and surcharges for excess use. Giving consumers the choice of violating quantity restrictions, even with substantial penalties and surcharges, will result in a willingness-to-pay to avoid the shortage that is not higher and most likely lower than if consumers have no choice but to obey the restrictions. Consumers may be better off in a system with surcharges for overuse because they can choose to consume additional water if they value its use more than the surcharge. This same point is argued by Mercer and Morgan (1989). They find that price-based rationing can reduce consumer welfare losses by two-thirds or more compared with pure physical rationing.

Conservation Programs. Voluntary retrofit programs presumably reduce the negative effects of shortage management programs as measured by willingness-to-pay. Mandatory retrofit programs may increase or decrease consumer welfare depending on how installation costs and reductions in user satisfaction balance against the benefits of mitigating shortage impacts. Public education programs can reduce welfare losses of water shortages in several ways. First, they may provide information that may enable consumers to better control their water use that would otherwise be difficult or costly to obtain. Second, they may decrease willingness to pay for water by increasing consumer awareness of the environmental consequences of diverting water for human uses. Third, they may decrease consumer willingness to pay by making water saving practices the norm. This could be termed the "moral cost" of continuing restricted water uses when neighbors are cutting back. Counterbalancing these positive gains is the likelihood the utility will increase rates to fund its conservation investments. Higher rates reduce consumer welfare. The net effect could be positive or negative depending on consumers' willingness-to-pay to avoid water shortages and the effectiveness and cost of the programs.

Welfare Effects of Shortage Polices on Commercial Enterprises

Water shortage management policies primarily affect firms that use water as an input to production, or as part of the goods and services they provide. Water supply cutbacks may affect the incomes of individuals who work for these firms, individuals who receive firm profits, and consumers who buy the firm's products.

Profits may fall in the face of higher prices both because firms must pay a higher cost for a given amount of water, and also because higher water costs may cause the firms to reduce the amount

of water consumed and production levels, eliminating the profit from units that are no longer produced. Similarly type-of-use and quantity restrictions may force the firm to reduce production from previously profitable levels.

Water shortages may also reduce the incomes of individuals who earn wages and salaries at firms if they cause firms to cut back on work hours or lay off workers. Water shortages may also reduce the demand for a firm's product and consequently its profits and wages and salaries. For example, restrictions on outdoor watering by residential users may decrease the demand for landscape products and services.

Evidence of Shortage-Induced Price Changes

Water shortages may induce water agencies to raise prices for water for two reasons. First, agencies may adopt pricing strategies, such as increasing block rates or excess use surcharges, to bring demand and supply into balance. Second, they may increase rates to offset revenue losses due to reduced sales. According to Loaiciga and Renehan (1997), both considerations were pertinent to the City of Santa Barbara. Between 1986 and 1996 the inflation-adjusted price of water more than tripled as a consequence of the prolonged drought between 1987 and 1991. By 1991, average use was driven to 50 percent of its pre-drought level, and by 1996, average use remained just 61 percent of its pre-drought level. Regardless of cause, higher prices for water reduce consumer welfare during shortages.

An analysis by RAND of 85 California urban water agencies during the 1987 to 1992 drought found that average revenue per acre-foot increased 33 percent between 1986 and 1990, and then jumped, on average, 16 percent from 1990 to 1991 (Dixon, et al., 1996). These increases varied by region, agency size, and customer class. Regional differences were greatest, indicating either differences in shortage severity or differences in shortage management policies. In the Bay Area, average revenues increased by more than 33 percent from 1990 to 1991, whereas in Southern California they increased by only 9 percent. For the remainder of the state, average revenues increased by 23 percent, on average.

There was little difference in the change in average revenue between 1990 and 1991 by agency size, suggesting the drought compelled small and large agencies alike to adjust their prices to manage demand and maintain revenue.

The percentage increase in average revenue per acre-foot was greatest for the industrial customer class and smallest for agricultural customer class. Between 1990 and 1991 average revenue from industrial customers increased by 22 percent compared to 16 percent for commercial customers and 14 percent for residential customers. Average revenue per acre-foot fom the agricultural class actually declined by 3 percent, suggesting that agricultural users were treated favorably during the shortage. The large percentage increase in average revenue from the industrial class in part may have been due to elimination of decreasing-block rates for this sector during this period -- a transition that had largely occurred already for the residential and commercial customer classes. It may also be that fixed charges account for a lower proportion of the total

bill for industrial customers, so that comparable increases in the variable charge for all customer classes result in a greater percentage increase in average cost of industrial customers.

Evidence of Shortage-Induced Changes in Economic Welfare

During the 1987-1992 drought, many water agencies in California were compelled to adopt drought policies to resolve supply and demand imbalances. These policies had varying effects by region and customer class.

The RAND survey reported the following distribution of cutbacks by customer class:

Table 2.
Percent Change in Water Use Between 1990 and 1991, by Customer Class

Customer Class	Percentage Change
Total Water Use	-12.4
Residential	-14.1
Single-Dwelling Unit	-19.3
Multiple-Dwelling Unit	-12.2
Commercial	-11.1
Industrial[a]	-15.6
Public Authority/Institutional	-23.0
Agricultural[a]	-24.8

[a]Increased groundwater pumping may have partially offset this decline in agency deliveries.

While all classes experienced sizable declines, the change in water use for single-family dwelling units, public authority/institutional, and agricultural classes was approximately 80 percent higher than the average change for the whole sample, though, according to the study's authors, reduced agricultural deliveries may have been largely offset by increased groundwater pumping. This data suggests impacts were concentrated mostly in the residential customer class, and within this class, mostly among single-family detached housing. To some extent commercial and industrial customer classes were shielded from shortages, through either water agency policies or the ability to substitute groundwater for agency deliveries. Within the commercial class, certain sectors were particularly affected by drought policies. As discussed in a later section of this

review, commercial impacts were concentrated mostly in the green industry (i.e. landscape installation, maintenance, and nursery businesses) and tourism sectors.

Residential Willingness-to-Pay Estimates

During the 1987-1992 drought, residential customers experienced nearly a 20 percent cutback in water use relative to 1986. A pilot study of the economic impacts of the drought on households living in single-family detached housing in Alameda County Water District found average losses per household in the range of $14-$23 as a result of water price increases over the period from July 1991 to December 1992, or $750,000 to $1,100,000 for the 54,000 households served by ACWD (Dixon, et al., 1996). The study only measured consumer welfare losses due to price increases. Type-of-use restrictions, which were not analyzed, may have caused additional losses if consumers would have been willing to pay the higher block rates for prohibited uses. While indicative of potential customer welfare losses caused by shortage-induced price increases, the study's authors warn against extrapolating the results to other districts or other parts of the state. First, because water demand relationships could vary in ways that are not captured by the models used in the analysis. Second, because of differences in water shortage management strategies adopted by different water agencies, with possibly very different effects on consumer welfare.

A 1994 study sponsored by California Urban Water Agencies measured consumer willingness-to-pay to avoid water shortages using contingent valuation survey techniques (Barakat & Chamberlin, 1994). This study estimated willingness-to-pay to avoid various shortage frequency and severity scenarios. Table 3 summarizes the mean willingness-to-pay findings reported by the study. These estimates measure the potential welfare loss to residential customers caused by water shortages. For example, the table shows that the average household willingness-to-pay to avoid a 20 percent shortage with a one-in-ten-year frequency was approximately $180 per year, or $1,800 over a 10-year period.

These results are consistent with a similar study conducted in 1987 by Carson and Mitchell (QED Research, 1987). This study also used contingent valuation survey techniques to elicit willingness-to-pay from residential water users. The mean willingness-to-pay estimates from this study are summarized in Table 4.

Table 3.
Mean Annual Willingness-To-Pay to Avoid Shortage/Frequency Scenario
(1999 Dollars)

Shortage (% of Full Service)	Shortage Frequency (Occurrences/Years)				
	1/30	1/20	1/10	1/5	1/3
10%			161.46	166.02	167.96
20%	162.01	171.42	180.97		
30%	181.66	191.48	201.44		
40%	202.13	212.37	222.75		
50%	223.44	234.09			

Source: Barakat & Chamberlin, Inc., "The Value of Water Supply Reliability: Results of a Contingent Valuation Survey of Residential Customers," California Urban Water Agencies, August 1994.

Table 4.
Carson & Mitchell 1987 WTP Results

Shortage Scenario	Annual Willingness-to-Pay (1999 Dollars)
10-15% once every 5 years	122
30-35% once every 5 years	167
10-15% twice every 5 years	223

Source: QED Research, Inc., "Economic Value of Reliable Water Supplies for Residential Water Users in the State Water Project Service Area." June 9, 1987.

Residential Landscape Losses

An analysis by the Phoenix Water and Wastewater Department estimated that a mandatory 50 percent curtailment in outdoor water use would cause $325 (1990 dollars) in landscape losses per household, on average (Dewitt, 1990). A similar study examining the effects of a 57 percent cutback in North Marin County during the 1977 drought estimated landscape losses of $390 (1979 dollars) per household (Hoffman, et al., 1979).

A field survey of Santa Barbara County landscapes conducted in 1990 estimated county-wide losses of private landscape totaling $217 million due to prolonged and severe drought and water rationing (Sycamore Associates and Spectrum Economics, 1992). This is approximately $1,500 per household. The study's authors attribute the majority of this loss ($181 million) to the replacement cost of lost turf, or $1,300 per household.[45]

Evidence of Commercial & Industrial Impacts

A 1992 survey of commercial and service firms in Southern California found that half of the responding firms had altered expansion plans or considered relocating because of concerns about water supply reliability (Foster Associates, 1993). Over 80 percent of the respondents indicated that the 1987-92 drought influenced their operations to some extent. All respondents indicated that the drought and associated water rationing had induced them to undertake some form of water conservation, and that rationing negatively affected their profits.

A 1991 survey of 238 manufacturers in 22 industries found frequent or persistent water shortages could result in potentially significant impacts to output and employment in many of California's key industrial sectors (Wade, et al., 1991). On average, 23 percent of the surveyed firms indicated they would reduce output in response to a 15 percent water shortage. This grew to 36 percent when the shortage scenario increased to 30 percent.[46]

From the survey data, the study's authors estimated the expected percentage change in output for a one-percent change in water supply shown in Table 5. Using SIC Code 203, Preserved Fruit & Vegetables, as an example, the table is read as follows: for a shortage up to 15 percent, each percentage increase in shortage is expected to reduce output in the Preserved Fruit & Vegetables sector by 0.27 percent. Thus, a 10 percent shortage is expected to reduce output in this category by 2.7 percent. If the shortage is between 15 and 30 percent, the expected reduction for a percentage increase in shortage is 0.35 percent. Thus, a 20 percent shortage is expected to reduce output in the Preserved Fruits & Vegetables sector by 7 percent.[47]

On the other hand, a 1991 study of 15 south San Francisco Bay Area industries found significant savings potential in at least some industries, perhaps suggesting that when industry is actually (rather than hypothetically) pushed to save water it can find ways to substantially reduce the use of water as a production input (Mazione and Maddaus, 1991). The study found that a variety of water conservation techniques -- ranging from employee education to major equipment retrofits -

[45] The study's authors note that "[i]t should be stressed that these values reflect a plant-by-plant assessment of value, which may overestimate the total value of the landscape. Ibid., page 13.

[46] It is important to note that these estimates are derived from survey responses to a hypothetical shortage. They are not empirically observed responses to an actual curtailment. The likelihood that actual response would deviate from hypothetical response is non-trivial.

[47] These estimates are derived from survey responses to two hypothetical shortage scenarios. They are not based on empirical measurement of actual response to a water shortage. Actual responses could significantly differ from those indicated in the survey.

-resulted in reductions in process water consumption of 25 to 90 percent, with payback periods ranging from two months to three years.

Landscape & Green Industry

A study of the effects of the 1987-1992 drought on California's Green Industry found that the loss of 4,500 jobs and $78 million in wages could be clearly attributed to water shortages in 1991 (Illingworth, 1994). The concurrence of economic recession in 1991 confounded the measurement of drought impacts, however. The study's authors reported that the combination of drought and recession resulted in an additional loss of 13,500 jobs and $230 million in wages and salaries.

Table 5.
Estimated Output Elasticity of Water for Key California Industries

		Shortage Scenario	
SIC Code	Industry	0-15%	15-30%
201	Meat Packing	0.00	0.00
203	Preserved Fruits & Vegetables	0.27	0.35
205	Bakery Products	0.70	0.90
208	Beverages	0.69	1.14
209	Misc. Food & Kindred Prod.	0.24	0.49
265	Paperboard Containers & Boxes	0.40	0.70
281	Industrial Inorganic Chemicals	0.12	0.20
283	Drugs	0.01	0.31
284	Soap, Cleansers & Toilet Goods	0.38	1.39
285	Paints & Allied Prod.	0.76	0.97
291	Petroleum Refining	0.44	0.85
327	Concrete, Gypsum, Plaster, Prod	0.17	0.19
344	Fabricated Metal Prod.	0.15	0.41
357	Computer & Office Equip.	0.18	0.27
366	Communication Equip.	0.00	0.01
367	Electronic Comp. & Acc.	0.07	0.33
371	Motor Vehicles	0.00	0.00
372	Aircraft & Parts	0.07	0.30
376	Guided Missiles, Space Veh & Parts	0.00	0.14

Source: Table 7-1, Wade, W., J. Hewitt, and M. Nussbaum, "Cost of Industrial Water Shortages," Spectrum Economics, Inc., prepared for California Urban Water Agencies. 1991.

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APPENDIX B

DETAILED SHORTAGE ALLOCATION TABLES

APPENDIX B: DETAILED SHORTAGE ALLOCATION TABLES

The following pages show the detailed demand breakdowns and shortage allocations across usage priorities and classes of service.

Santa Cruz Shortage Allocation		TOTAL	Single Family		Multi-Family		Business (incl. Agriculture)		UCSC		Large Landscape	Golf	Industrial	Municipal	Misc.	WWTP
Year: 2000																
Peak Season Base Demands (mg):		2,830	1,043		601		578		138		135	117	155	41	8	13
			Indoor	Outdoor	Indoor	Outdoor	Sanitary	Non-Sanitary	Indoor	Outdoor						
			661	382	428	173	163	415	97	41						
Drought Scenario 0 Allocations																
System Shortage:	*0%*															
Priority: Health/Safety (gpcd)	***60.7***	934	661				163		97							13
	52.5	428			428											
Business	***0%***	736						415				117	155	41	8	
Landscape	***0%***	732		382		173				41	135					
Subtotals			661	382	428	173	163	415	97	41						
GPCD			60.7	35.0	52.5	21.3										
% Reduction			0%	0%	0%	0%	0%	0%	0%	0%						
TOTAL		2,830	1,043		601		578		138		135	117	155	41	8	13
% Reduction		0%	0%		0%		0%		0%		0%	0%	0%	0%	0%	0%

Santa Cruz Shortage Allocation		TOTAL	Single Family		Multi-Family		Business (incl. Agriculture)		UCSC		Large Landscape	Golf	Industrial	Municipal	Misc.	WWTP
Year: 2000																
Peak Season Base Demands (mg):		2,830	1,043		601		578		138		135	117	155	41	8	13
			Indoor	Outdoor	Indoor	Outdoor	Sanitary	Non-Sanitary	Indoor	Outdoor						
			661	382	428	173	163	415	97	41						
Drought Scenario 1 Allocations																
System Shortage: *10%*																
Priority: Health/Safety (gpcd)	*60.7*	934	661				163		97							13
	52.5	428			428											
Business	*5%*	699						394				111	147	39	7	
Landscape	*30%*	512		267		121				29	95					
Subtotals			661	267	428	121	163	394	97	29						
GPCD			60.7	24.5	52.5	14.9										
% Reduction			0%	30%	0%	30%	0%	5%	0%	30%						
TOTAL		2,573	929		549		557		126		95	111	147	39	7	13
% Reduction		9%	11%		9%		4%		9%		30%	5%	5%	5%	5%	0%

Santa Cruz Shortage Allocation		TOTAL	Single Family		Multi-Family		Business (incl. Agriculture)		UCSC		Large Landscape	Golf	Industrial	Municipal	Misc.	WWTP
Year: 2000																
Peak Season Base Demands (mg):		2,830	1,043		601		578		138		135	117	155	41	8	13
			Indoor	Outdoor	Indoor	Outdoor	Sanitary	Non-Sanitary	Indoor	Outdoor						
			661	382	428	173	163	415	97	41						
Drought Scenario 2 Allocations																
System Shortage:	***20%***															
Priority: Health/Safety (gpcd)	***56.8***	873	619				152		90							12
	49.3	401			401											
Business	***15%***	626						353				100	131	35	7	
Landscape	***50%***	366		191		87				21	68					
Subtotals			619	191	401	87	152	353	90	21						
GPCD			56.8	17.5	49.3	10.6										
% Reduction			6%	50%	6%	50%	6%	15%	6%	50%						
TOTAL		2,266	809		488		505		111		68	100	131	35	7	12
% Reduction		20%	22%		19%		13%		20%		50%	15%	15%	15%	15%	6%

Santa Cruz Shortage Allocation		TOTAL	Single Family		Multi-Family		Business (incl. Agriculture)		UCSC		Large Landscape	Golf	Industrial	Municipal	Misc.	WWTP
Year: 2000																
Peak Season Base Demands (mg):		2,830	1,043		601		578		138		135	117	155	41	8	13
			Indoor	Outdoor	Indoor	Outdoor	Sanitary	Non-Sanitary	Indoor	Outdoor						
			661	382	428	173	163	415	97	41						
Drought Scenario 3 Allocations																
System Shortage: 30%																
Priority: Health/Safety (gpcd)	52.3	805	570				140		83							11
	45.7	372			372											
Business	25%	552						311				88	116	31	6	
Landscape	60%	293		153		69				17	54					
Subtotals			570	153	372	69	140	311	83	17						
GPCD			52.3	14.0	45.7	8.5										
% Reduction			14%	60%	13%	60%	14%	25%	14%	60%						
TOTAL		2,022	723		442		452		100		54	88	116	31	6	11
% Reduction		29%	31%		27%		22%		28%		60%	25%	25%	25%	25%	14%

Santa Cruz Shortage Allocation		TOTAL	Single Family		Multi-Family		Business (incl. Agriculture)		UCSC		Large Landscape	Golf	Industrial	Municipal	Misc.	WWTP
Year: 2000																
Peak Season Base Demands (mg):		2,830	1,043		601		578		138		135	117	155	41	8	13
			Indoor	Outdoor	Indoor	Outdoor	Sanitary	Non-Sanitary	Indoor	Outdoor						
			661	382	428	173	163	415	97	41						
Drought Scenario 4 Allocations																
System Shortage:	***40%***															
Priority: Health/Safety (gpcd)	***47.9***	736	522				128		76							10
	41.5	338			338											
Business	***30%***	433						291					108	29	5	
Landscape	***75%***	212		95		43				10	34	29				
Subtotals			522	95	338	43	128	291	76	10						
GPCD			47.9	8.8	41.5	5.3										
% Reduction			21%	75%	21%	75%	21%	30%	21%	75%						
TOTAL		1,720	617		381		419		87		34	29	108	29	5	10
% Reduction		**39%**	**41%**		**37%**		**27%**		**37%**		**75%**	**75%**	**30%**	**30%**	**30%**	**21%**

Santa Cruz Shortage Allocation		TOTAL	Single Family		Multi-Family		Business (incl. Agriculture)		UCSC		Large Landscape	Golf	Industrial	Municipal	Misc.	WWTP
Year:	2000															
Peak Season Base Demands (mg):		2,830	1,043		601		578		138		135	117	155	41	8	13
			Indoor	Outdoor	Indoor	Outdoor	Sanitary	Non-Sanitary	Indoor	Outdoor						
			661	382	428	173	163	415	97	41						
Drought Scenario 5 Allocations																
System Shortage:	*50%*															
Priority: Health/Safety (gpcd)	*43.9*	675	478				118		70							9
	38.3	312			312											
Business	*35%*	402						270					101	27	5	
Landscape	*100%*	0		0		0				0	0	0				
Subtotals			478	0	312	0	118	270	70	0						
GPCD			43.9	0.0	38.3	0.0										
% Reduction			28%	100%	27%	100%	28%	35%	28%	100%						
TOTAL		1,389	478		312		388		70		0	0	101	27	5	9
% Reduction		51%	54%		48%		33%		49%		100%	100%	35%	35%	35%	28%

Santa Cruz Shortage Allocation		TOTAL	Single Family		Multi-Family		Business (incl. Agriculture)		UCSC		Large Landscape	Golf	Industrial	Municipal	Misc.	WWTP
Year: 2000																
Peak Season Base Demands (mg):		2,830	1,043		601		578		138		135	117	155	41	8	13
			Indoor	Outdoor	Indoor	Outdoor	Sanitary	Non-Sanitary	Indoor	Outdoor						
			661	382	428	173	163	415	97	41						
Drought Scenario 6 Allocations																
System Shortage:	***60%***															
Priority: Health/Safety (gpcd)	***35.0***	539	381				94		56							7
	32.2	262			262											
Business	***50%***	309						208					77	21	4	
Landscape	***100%***	0		0		0				0	0	0				
Subtotals			381	0	262	0	94	208	56	0						
GPCD			35.0	0.0	32.2	0.0										
% Reduction			42%	100%	39%	100%	42%	50%	42%	100%						
TOTAL		1,110	381		262		302		56		0	0	77	21	4	7
% Reduction		**61%**	**63%**		**56%**		**48%**		**60%**		**100%**	**100%**	**50%**	**50%**	**50%**	**42%**

APPENDIX C

RESIDENTIAL FOCUS GROUP DESCRIPTION

APPENDIX C: RESIDENTIAL FOCUS GROUP DESCRIPTION

On May 8 and 9, 2000, one focus group each was conducted for single-family and multi-family customers. The goal of these sessions was to gain additional insight into the likely actions that residential customers would take to achieve drought-related water demand reductions of various magnitudes, and the degree and type of hardship that these actions would impose on these customers. Following is a discussion of how these groups were conducted and an analysis of the results.

DESCRIPTION OF FOCUS GROUPS

Group participants were recruited by Water Department staff. An attempt was made to achieve some demographic diversity, particularly in terms of age and location of residence.[48]

Each session lasted approximately two hours, including a brief break. Participants were provided with dinner and were compensated for their participation. The single-family and multi-family groups were conducted in almost identical fashion. The lone exception was the fact that multi-family customers were asked to limit their responses only to indoor water-saving actions, while single-family customers were able to consider both indoor and outdoor actions. This distinction was made because most multi-family customers do not control the bulk of the outdoor uses in their complex.

In each group, participants were given forms on which they were successively asked to indicate the three most likely actions they would take if required to reduce their summer water usage by 10%, 30%, and 50%. For each action, they were also asked to indicate the degree and type of hardship that action would impose on them. To assist them to respond to these questions, participants were shown a list of common residential water uses. (Multi-family customers were shown only indoor uses.) After participants completed their written responses at each level, they were given an opportunity to discuss and explain their responses.

Participants were then given some additional information on typical breakdowns of per-person water uses in single-family or multi-family households, as appropriate. Single-family participants were provided with:

- A pie chart which broke down typical usage into indoor and outdoor portions.
- A pie chart which broke down typical indoor usage into key end uses, including toilet flushing, showering, clothes washing, dishwashing, faucet use, and leaks/other.

[48] No claim is made that these groups are statistically representative of the population of the Santa Cruz Water Department's service area. The results therefore are at most indicative of what might be expected from water customers. This disclaimer is typical of focus group research.

- A table showing typical frequency and duration for key indoor uses.

Multi-family participants were provided with:

- A pie chart which broke down typical indoor usage into key end uses, including toilet flushing, showering, clothes washing, dishwashing, faucet use, and leaks/other.
- A table showing typical frequency and duration for key indoor uses.

With this information in hand, participants were then given another set of forms (identical to the first set) and asked the same questions again. Discussion focused on whether responses had changed and the reasons for those changes.

FINDINGS

While quantification of participant responses is valuable, a large portion of the value of a group such as this comes from some of the qualitative impressions that result from the group's discussions. Accordingly, this section first discusses some quantitative results and then addresses some more qualitative issues.

Quantitative Analysis

Water-saving actions. Table 1 provides tallies of the number of participants who mentioned particular categories of water-saving actions, regardless of the level or type of hardship. These figures are provided at each level of shortage (i.e. 10%, 30%, and 50%) and for responses prior to ("pre") and subsequent to ("post") the provision of the additional information on residential water uses. Two of the categories require additional explanation:

1. *Substitution* includes any action which physically substitutes for water use in the home. Examples include:

- Drinking bottled water
- Showering at health club
- Washing clothes at laundromat

(Note that the latter two do not necessarily reduce total demand on the Santa Cruz system.)

2. *Capital replacement* includes any investment to replace existing fixtures, equipment, or landscape materials to increase water use efficiency.

Table 1
Drought Actions Reported by Focus Group Participants

	Showers	Toilets	Clothes Washer	Dish Washer	Faucet	Substitution	Leak Repair	Grey Water	Outdoor Washing	Outdoor Irrigation	Capital Replacement	Other
Single-Family (N=11)												
10% Shortage												
Pre	7	4	5	3	6	0	2	0	3	3	0	1
Post	9	6	8	0	3	1	0	0	2	2	0	0
30% Shortage												
Pre	3	2	5	4	4	3	1	0	1	7	2	2
Post	5	5	5	0	7	2	1	1	2	5	1	1
50% Shortage												
Pre	4	5	3	1	2	3	0	2	1	6	3	3
Post	6	5	5	0	3	1	0	1	1	5	3	3
Multi-Family (N=6)												
10% Shortage												
Pre	6	3	4	1	3	1	0	0	N/A	N/A	0	0
Post	5	2	3	2	2	0	1	0	N/A	N/A	0	0
30% Shortage												
Pre	6	3	3	3	2	2	0	0	N/A	N/A	0	2
Post	5	2	4	2	3	2	2	0	N/A	N/A	0	0
50% Shortage												
Pre	6	3	3	1	2	1	0	0	N/A	N/A	0	1
Post	4	4	5	2	1	2	0	2	N/A	N/A	0	0

While it is difficult to extract any definitive trends from Table 2, it appears that single-family focus group participants believe that, in mild droughts (requiring a 10% usage reduction), they would rely more heavily on behavioral changes, such as shorter or less frequent showers, and reductions in toilet flushing, clothes washing, dishwashing, faucet use, and washing of outdoor surfaces. As the severity of the drought increases, changes in outdoor irrigation are reported more frequently, as are substitution activities and capital replacement.

Perhaps because of the smaller size of the multi-family focus group and the smaller number of water-reduction actions available, no trends emerge in Table 2. Not surprisingly, multi-family customers did not report any capital investments.

For each group as a whole, the anticipated actions reported after the water-usage information was presented differed significantly from those actions reported prior to that presentation. (The issue of changes in responses is discussed in more detail in the subsection below titled "Impact of

Degree of hardship. Table 2 compares the degree of anticipated hardship ("little or no", "some", t different levels of shortage before and after the presentation of the water usage information. Not unexpectedly, the degree of hardship increases significantly as the shortage magnitude gets larger. Perhaps more surprisingly, even at a 50% shortage level, only about one-fourth of single-family and 40% of multi-family participants' responses reported "considerable" hardship. (Particularly for single-family participants, these figures must be viewed in conjunction with the tone and content of the group discussion, which will be addressed below.) Table 3 shows no particular difference in the hardship levels reported before and after the informational presentation.

Type of hardship. Table 3 provides information on the types of hardship participants expected to experience at different shortage levels. In the minds of single-family participants, milder shortages are expected to result primarily in inconvenience, with very few economic or health and safety impacts. In contrast, more severe droughts are expected to result in many more economic or health and safety impacts. Provision of the water usage information appears to have resulted in more perceived inconvenience and fewer health and safety impacts.

The trend differs somewhat for multi-family participants, with inconvenience giving way to more aesthetic and health and safety impacts as shortages increase.

Impact of information. As pointed out above, the aggregate responses of each group changed after the water usage information was presented. Table 4 addresses the extent of change in individuals' responses. The results indicate that, for a significant fraction of participants, responses after the presentation of the additional information differed from the prior responses at all three drought levels. As will be discussed below, it is not necessarily the case that all these changes resulted from the water usage information. While a large portion of the changes were certainly due to the information, some participant comments indicated that the changes may have

Table 2
Degree of Hardship Reported [1]

	Little or No	Some	Considerable
Single-Family (N=11)			
10% Shortage			
Pre	69%	29%	3%
Post	65%	35%	0%
30% Shortage			
Pre	25%	64%	11%
Post	33%	53%	13%
50% Shortage			
Pre	18%	61%	21%
Post	25%	50%	25%
Multi-Family (N=6)			
10% Shortage			
Pre	61%	39%	0%
Post	87%	13%	0%
30% Shortage			
Pre	45%	55%	0%
Post	56%	31%	13%
50% Shortage			
Pre	0%	63%	37%
Post	0%	61%	39%

[1] Percentages of total responses at each shortage level.

Table 3
Type of Hardship Reported [1]

	Inconvenience	Aesthetic	Economic	Health & Safety
Single-Family (N=11)				
10% Shortage				
Pre	67%	25%	0%	8%
Post	84%	6%	9%	0%
30% Shortage				
Pre	29%	27%	32%	12%
Post	39%	24%	26%	11%
50% Shortage				
Pre	15%	26%	33%	26%
Post	27%	31%	27%	16%
Multi-Family (N=6)				
10% Shortage				
Pre	67%	22%	6%	6%
Post	68%	21%	0%	11%
30% Shortage				
Pre	42%	46%	4%	8%
Post	49%	36%	5%	10%
50% Shortage				
Pre	28%	48%	3%	21%
Post	38%	34%	9%	19%

[1] Percentages of total responses at each shortage level.

Table 4

Overall Changes in Reported Drought Actions and/or Hardship [1]

	Showers	Toilets	Clothes Wash	Dish Wash	Faucet	Substitution	Leaks	Grey Water	Outdoor Washing	Outdoor Irrigation	Other	TOTAL
Single-Family (N=11)												
10% Shortage	4 36%	7 64%	8 73%	3 27%	4 36%	1 9%	2 18%	0 0%	2 18%	2 18%	1 9%	**34** **28%**
30% Shortage	5 45%	6 55%	6 55%	4 36%	5 45%	2 18%	1 9%	1 9%	2 18%	4 36%	3 27%	**39** **32%**
50% Shortage	7 64%	5 45%	4 36%	1 9%	4 36%	3 27%	0 0%	1 9%	1 9%	5 45%	1 9%	**32** **26%**
Multi-Family (N=6)												
10% Shortage	2 33%	3 50%	5 83%	1 17%	2 33%	1 17%	1 17%	0 0%	N/A	N/A	0 0%	**15** **28%**
30% Shortage	5 83%	4 67%	4 67%	4 67%	3 50%	2 33%	2 33%	0 0%	N/A	N/A	0 0%	**24** **44%**
50% Shortage	4 67%	4 67%	4 67%	2 33%	2 33%	4 67%	0 0%	2 33%	N/A	N/A	0 0%	**22** **41%**

[1] Number and percent of participants who either added or deleted the action or changed the degree or type of hardship associated with the action.

Table 5

Detail of Changes in Reported Drought Actions and/or Hardship [1]

	Add Action	Increase Hardship Degree	"Increase" Hardship Type	Remove Action	Reduce Hardship Degree	"Reduce" Hardship Type
Single-Family (N=11)						
10% Shortage	11	2	1	15	1	5
30% Shortage	16	2	1	14	1	13
50% Shortage	13	3	1	8	3	2
Multi-Family (N=6)						
10% Shortage	4	0	1	7	3	1
30% Shortage	8	1	1	7	0	7
50% Shortage	6	0	0	3	0	6

[1] Number of participants who reported indicated type of change

been due to ideas mentioned by others or simply to new thoughts that had not come to mind earlier.

The results reported in Table 4 are disaggregated in a different manner in Table 5. Here, the reported changes are broken into six categories. Either an action was added or removed, the degree of hardship was increased or reduced, or the type of hardship was changed. For purposes of this table, the hardship types are assumed to increase in severity, with "inconvenience" being the least severe, "health and safety" the most severe, and "aesthetic" and "economic" being of equal severity.[49]

The most frequent changes reported were either the addition or removal of an action. These occurred with about equal frequency. In contrast, changing the hardship degree of a given action occurred very seldom. Perhaps the most interesting result in Table 5 is the reported changes in the type of hardship reported. While there were very few reports of more burdensome types of hardships, there were a great number of shifts to less burdensome hardship types. This supports the notion that the information led participants to reduce their expectations of the problems that future droughts would impose.

Qualitative Analysis

The foregoing results must be viewed in conjunction with an examination of the comments made by group members. Several key themes emerged from the discussions:

Reactions to drought severity. As expected, both groups became increasingly concerned as the severity of the hypothetical drought increased. However, the reactions of the single-family participants were much sharper than those of the multi-family participants. Single-family participants expressed anger at the perceived possibility of a 50% curtailment. One participant noted that this would be a "major public crisis." Another mentioned the word "revolution" and another talked of "marches in the streets." Mention was made of the perceived inability of the City to deal with the water supply crisis. A few refused to even consider possible actions to respond to such an "impossible" shortage.

Multi-family participants were not nearly as vocal in their reactions to large shortages. While they were certainly unhappy about the prospect of curtailments as large as 50%, it is fair to say that they took the possibility of such a shortage more in stride. Little anger was expressed.

These different responses to large curtailments are in contrast to the written responses described above. As shown in Table 3, one-fourth to one-third of the actions anticipated by single-family participants in the event of a 50% curtailment were characterized as having "little or no" impact, while only one-fourth or less had "considerable" impact. In contrast, at the 50% curtailment

[49] The comments of participants tend to support this ordering of the hardship categories.

level, multi-family participants reported no actions with "little or no" impact; 40% were described as having "considerable" impact.

Unfortunately, the time constraints of the focus groups did not afford us the opportunity to explore these apparent discrepancies between "gut" responses to the situation of large shortages and the perceived difficulty of individual actions. One possible explanation for the apparent inconsistency of the single-family responses is that although each action taken in isolation may have been seen as having moderate impacts, the cumulative impact may have been viewed as quite severe. Alternatively, the inconsistency may reflect the inherent difficulty of the task that participants were being asked to perform.

Difficulty of task. Asking citizens to quickly determine actions to be taken in a future hypothetical drought and the impacts of those actions is an inherently difficult task. These are not issues that most people think about very often; their responses in a setting such as this must therefore be seen as little more than preliminary indicators of what they actually would do when faced with the situation. The discussion indicated that the task was especially difficult for some of the multi-family participants. This is not surprising, since these customers do not pay a water bill and typically have control over many fewer water uses than their single-family counterparts.

Benefit of water usage information. Virtually all customers reacted very favorably to the tables and pie charts of typical water usage they were given. A number of participants particularly liked the pie chart of indoor end uses. Many expressed surprise at some of the information (e.g. that toilet flushing is such a large portion of indoor use), and appreciated receiving it. Some participants expressed relief, saying the information led them to conclude that they would have to do less to achieve each level of curtailment than they had originally thought.

Participants uniformly felt that such information would help customers respond to a drought. A number of the participants, who initially voiced concern that it was difficult to know if the actions they had selected would result in the specified reduction, seemed to have more confidence in their ability to make this determination after the information was presented.

As described above, many of the initial responses changed after considering the information. However, there is reason to question the quality of the link between the information provided and the changes in responses:

- Several participants reported that the changes in their responses were due more to additional thought and/or ideas presented by others in the group rather than the information provided.

- When asked what components of the information led to their changes, some participants reported that they changed their actions to correspond more to the end uses that consumed the most water, in spite of the fact that they may have been concerned with the impacts that those actions might impose on them. Thus, for example, while some participants remarked on the amount of water used by toilet flushing and said that as a result they would increase their focus on that end-use, they also voiced increased concern about health and safety and aesthetics.

- It became apparent that a number of participants did not employ the usage breakdowns as a way to match the cumulative impact of actions with the desired curtailment level. (Participants were not explicitly instructed to do so.)

- Participants had to be strongly reminded by the moderator that the breakdowns given were for a "typical" household and might not apply to any participant's individual situation. Even with these admonishments, it seemed difficult for participants to modify these typical results to reflect their own household characteristics. This was particularly true of the breakdown between indoor and outdoor usage, which varies considerably among residential customers.

- When asked what other information they might find useful, several participants said they wanted more specific information on different combinations of actions a typical household could take to achieve a certain level of reduction.

All of these points are associated in large measure with the manner in which these groups had to be structured and the stringent time limitations imposed on customers as they reviewed and interpreted the information. Given more time to reflect on the information, customers will more likely make better use of it.

Equity concerns. In the single-family group, several articulated a concern that, since they have already "hardened" their demand by adopting water-conserving behaviors or technologies, they would be unfairly burdened if asked to reduce their demand by the same percentage as their non-conserving neighbors. This issue speaks directly to the manner in which the City of Santa Cruz will manage future droughts. It should be noted that the City's current Water Shortage Contingency Plan does, in fact, rely on residential usage allotments, rather than uniform percentage reductions.

CONCLUSIONS

The focus group results are one of several types of information that will be combined to draw conclusions regarding the impacts of future drought-related shortages on Santa Cruz water customers. Focus groups are not intended to provide precise answers. The purpose of these groups was to hear directly from a group of residential customers on their reactions to potential future droughts. Based on a combination of quantitative and qualitative analyses, we can draw the following conclusions:

- It is difficult to extract any definitive trends from the focus group results regarding the water-saving actions that customers will take in response to future droughts. There is some evidence that participants, particularly single-family participants, recognize that while in mild droughts they could rely on behavioral changes, droughts of greater magnitude will require more stringent actions such as economic substitution and capital replacement.

- In general, participants do not view a 10% shortage as a significant event. A 30% shortage is much more important, but generally seen as manageable. At least in the case of single-family customers, a 50% shortage is viewed as a near-catastrophic and unacceptable occurrence.

- Smaller shortages are viewed as inconveniences. Larger shortages are anticipated to result in economic or aesthetic losses and possible dangers to health and safety.

- The provision of basic information on water usage was widely thought to enhance the ability of participants to deal with drought. While the focus groups could not allow us to draw firm conclusions on the most useful type of information or the precise manner in which customers will use it, basic information appears to reduce customers' "fear factor," as demonstrated by the greater tendency to describe drought impacts in less onerous terms after considering the usage information. However, it is also clear that the Water Department must carefully consider the form and substance of the information to be provided to customers in the event of a drought. For example, information on "typical" usage could be misleading. One possibility is to tailor information to different customer categories.

APPENDIX D

REPORT ON LANDSCAPE IMPACTS

APPENDIX D: REPORT ON LANDSCAPE IMPACTS

INTRODUCTION

The City of Santa Cruz is well-known for its scenic location, nestled between the Pacific Ocean and the redwood covered Santa Cruz Mountains, as well as the beautiful landscaping found in many of its neighborhoods. Mandatory water curtailment during a drought would have an impact on the aesthetic and economic value of landscapes throughout the city.

This purpose of this study was to estimate the impact of water curtailments on residential, commercial/industrial, and large landscapes throughout the City of Santa Cruz.

METHODS

Sycamore Associates retained the services of Barrie Coate and Associates, Horticultural Consultants to conduct a field assessment of the impact of water curtailments on residential, commercial/industrial and large landscapes in the City of Santa Cruz. Dr. Coate reviewed relevant background literature, including *The Costs of Water Shortages: Case Study of Santa Barbara* (Spectrum Economics and Sycamore Associates, October 16, 1991), *Drought Conditions in California* (State of California, September 1990), and the *Urban Water Management Plan* (Toby Goddard for City of Santa Cruz Water Department, January 1996).

In order to evaluate the impact of a realistic range of water curtailments on landscapes, it was determined to assess the impact of three levels of outdoor water curtailments; 30%, 65% and 100%, on a variety of landscapes in Santa Cruz. The overall water curtailment numbers, including indoor and outdoor usage are provided elsewhere. This study focuses on outdoor curtailment only. These levels were chosen because they represent the potential range of irrigation water reduction, and provide enough breadth to allow for a meaningful comparison between different levels of water availability.

RESIDENTIAL LANDSCAPES

The City of Santa Cruz was divided into unique, non-overlapping units for the 2000 U.S. census. Census tracts were used in the present study to subdivide the City into units that could be intensively surveyed. Six census tracts were selected for residential landscape evaluation. Selected tracts included 1001, 1002, 1213, 1215, 1006 and 1005, which were chosen because they represent the full range of housing and landscaping commonly found in Santa Cruz. These tracts were visited by Dr. Coate. A quick driving tour of each tract was conducted to select a typical neighborhood representative of the rest of the tract. Six landscapes in each tract were then visually assessed, noting the estimated area of turf, shrubs, intensively gardened beds (vegetable and/or flower gardens) and total number of trees. The assessment was conducted from the sidewalk or street at the front of the house;

backyards and side yards were not entered, but the landscapes in those areas was estimated from what was visible from the front of the house and surrounding landscapes.

The impact of 30, 65 and 100% outdoor water curtailment was then estimated for each landscape component (turf, shrubs, intensively gardened and trees) for each residential unit. The analysis considered a number of factors that would affect the drought-hardiness of the landscape including: age of landscape, species present and their relative drought hardiness, soil type, evidence of maintenance and irrigation, disease or pest problems, topography, and aspect/exposure.

COMMERCIAL/INDUSTRIAL

A driving survey through the downtown commercial area, numerous neighborhood commercial areas, shopping centers, office developments and the limited industrial area of Santa Cruz was conducted. Visual assessments of landscaped areas were performed. These landscapes were surveyed from the street, and in most cases, the landscaping for these areas is concentrated near the front of the building/development. The impact of 30, 65 and 100% outdoor water curtailment on the landscape was estimated for each surveyed area.

LARGE LANDSCAPE

Large landscapes include City parks and golf courses. The University of California at Santa Cruz campus was not included in this survey.

As with the residential and commercial/industrial areas, these large landscapes were subdivided into water demand components (turf, shrubs, intensively gardened and number of trees) and the impact of the 30, 65 and 100% outdoor water curtailments were estimated. Surveyed landscapes included DeLaviaga Park, golf course and neighborhood parks.

RESULTS

The impact of 30, 65 and 100% outdoor water curtailments were assessed in terms of loss of value. The estimates of loss in this analysis do not in most cases, denote entire loss in the short term of the landscape plants, but partial loss of their aesthetic value. Loss of aesthetic value influences real estate values, commercial values of businesses and both market and non-market recreational values.

Tables 1 and 2 report the areas of landscaping by component, and the impact of water curtailments on residential and large landscapes, respectively. Landscapes and the impacts of water curtailments on commercial and industrial landscapes were not

quantitatively surveyed, but were visually assessed during drive-through tours. Results of the driving surveys are described in narrative form.

Residential

Table 1 summarizes the average area of residential landscape by landscape component (area of turf, shrubs, intensively gardened and number of trees) for each of the six census tracts sampled. The range of landscaped areas and numbers of trees is depicted. The average impact associated with each of the three levels of water curtailment is shown, as well as the range of impacts to landscape value. City-wide averages are provided at the bottom of Table 1.

Relatively modest losses of value would occur in the 30% outdoor curtailment scenario. Not surprisingly, intensively gardened areas and turf would suffer the greatest losses, with 21% and 24% value losses, respectively. While there is some variability in landscaped areas and numbers of trees between census tracts, the overall impact of a 30% mandatory reduction in irrigation water would be relatively minor. Given the relative drought tolerance of most trees and shrubs in residential landscapes in Santa Cruz, as evidenced by the estimated value losses of only 7% and 6% respectively, residents might be advised to focus limited irrigation water on the most vulnerable components of their landscapes; the turf and intensively gardened areas.

The predicted impact on landscape value associated with a 65% curtailment is fairly severe. Not surprisingly, turf and intensively gardened areas would be hard hit, with City-wide average losses of 50 and 59% respectively. Shrubs and trees would also sustain moderate loss of value, with 25% loss of value for shrubs and 22% for trees. With a 65% curtailment, residents would find it difficult to maintain valuable landscapes, even if they employed a triage approach of only watering the most vulnerable or valuable portions of their landscapes.

Severe losses in landscape value are predicted under a 100% curtailment scenario. Turf and intensively gardened areas would sustain the highest levels of loss, with City-wide average losses of 82 and 80% respectively. Losses of value in trees and shrub areas would also be significant, at 38% value loss for trees and 43% for shrub areas.

Averaging the data across census tract and the City of Santa Cruz may obscure the more extreme impacts that would occur if water supplies were curtailed for individual landscapes. A number of residential landscapes were predicted to sustain major impacts to landscape value even under the 30% curtailment scenario. More vulnerable landscapes, namely those with landscape components that are not drought tolerant will suffer greater losses in value under any water supply curtailment. Conversely, a number of the landscapes sampled would suffer virtually no impact from any level of water

TABLE 1: SUMMARY OF RESIDENTIAL LANDSCAPE AREAS AND IMPACT OF OUTDOOR CURTAILMENT

Census Tract	**Typical Landscape** Average Area Measured in Square Feet	(Range)	**30% Curtailment Average % Loss in Value** (Range of Value Loss)		**65% Curtailment Average % Loss in Value** (Range of Value Loss)		**100% Curtailment Average % Loss in Value** (Range of Value Loss)	
1001	Turf 783	(600-1000)	30	(10-65)	70	(20-100)	90	(60-100)
			12	(0-30)	45	(0-50)	67	(60-80)
	Trees 19	(0-60)	8	(0-20)	23	(10-50)	41	(20-80)
	Shrubs 450	(200-1000)	32	(10-50)	68	(20-100)	85	(60-100)
	Intensive 250	(0-400)						
1002	Turf 667	(0-1000)	16	(0-50)	54	(40-100)	100	(all 100)
	Trees 3	(0-6)	11	(0-30)	34	(0-65)	54	(0-80)
	Shrubs 327	(0-600)	7	(0-25)	29	(0-65)	44	(0-80)
	Intensive 130	(0- 300)	28	(0-50)	83	(65-100)	100	(all 100)
1213	Turf 700	(0-2000)	20	(10-50)	41	(30-65)	75	(60-100)
	Trees 3	(0-5)	10	(0-30)	26	(0-65)	45	(0-100)
	Shrubs 717	(200-2000)	8	(0-30)	28	(0-60)	53	(0-80)
	Intensive 100	(0-400)	10	(all 10)	55	(30-80)	80	(60-100)
1215	Turf 700	(0-1000)	12	(10-20)	34	(30-50)	64	(60-80)
	Trees 2	(0-4)	2	(0-10)	9	(0-30)	17	(0-60)
	Shrubs 1333	(400-4000)	2	(0-10)	19	(0-30)	29	(0-60)
	Intensive 100	(0-600)	20	(all 20)	50	(all 50)	80	(all 80)
1006	Turf 1700	(0-6000)	24	(0-30)	52	(0-65)	80	(0-100)
	Trees 7	(4-8)	5	(0-10)	20	(0-30)	44	(20-65)
	Shrubs 1967	(400-6000)	4	(0-10)	18	(0-30)	40	(20-65)
	Intensive 700	(0-1600)	16	(10-30)	38	(0-65)	67	(20-100)
1005	Turf 1633	(0-4500)	22	(10-30)	51	(30-65)	80	(50-100)
	Trees 2	(0-4)	0	(all 0)	0	(all 0)	0	(all 0)
	Shrubs 717	(400-1200)	7	(0-20)	32	(10-80)	50	(30-80)
	Intensive 383	(0-600)	36	(0-100)	58	(20-100)	70	(40-100)
Average All Census Tracts	Turf 1030		21		50		82	
	Trees 6		7		22		38	
	Shrubs 919		6		25		43	
	Intensive 277		24		59		80	

TABLE 2: SUMMARY OF LARGE LANDSCAPE AREAS AND IMPACT OF OUTDOOR CURTAILMENT

Type of Landscape	Area of Landscaping Percent of area[1]	30% Curtailment Average % Loss in Value	65% Curtailment Average % Loss in Value	100% Curtailment Average % Loss in Value
Golf Course DeLaviaga	Turf 90 Trees 5 Shrubs 1	30 20 0	65 40 0	100 60 0
Parks Winkle Farm Park	Turf 90 Trees 10 Shrubs 0	30 10 0	60 30 0	100 80 0
DeLaviaga Park	Turf 50[2] Trees 50[2] Shrubs			

[1] These figures represent the relative area of the large landscape covered with that type of landscape component rather than a physical measurement of square foot area.

[2] These relative areas for turf and trees are rough estimates; a more accurate estimate could be developed with the use of an aerial photo, which was not available for the present study.

curtailment either because the landscapes were already completely unmaintained or because the landscapes were composed of highly drought-resistant native species.

At 65% curtailment, many landscape components are predicted to lose 100% of their value. Again, it is apparent that selected landscapes are extremely vulnerable to water curtailment, while others have relative durability during a drought.

Under a 100% water curtailment scenario, many landscapes are predicted to lose 100% of their value. Even at the lowest range of value losses, impacts would be very pronounced.

Water curtailment would be invoked during drought conditions, when landscapes are already under stress because rainfall is less than normal. While the extent to which the impact of water curtailment would exacerbate the loss of landscape value associated with the drought conditions was not quantitatively assessed during the field surveys, it is an important issue that merits recognition. During a drought, landscapes are expected to receive below-average rainfall, resulting in drought-stress independent of water curtailment imposed by the City. Soils that normally recharge with moisture during fall, winter and spring rainfall will be more dry during a drought, leading to potential declines in landscape vigor and increased susceptibility to pests and pathogens. The impacts of a drought may compound the impact of water curtailment, potentially increasing the severity of landscape value loss noted in Table 1.

Individual residential landscape analyses, discussions and photos of representative landscapes are contained in Attachment A.

Large Landscape

De Laveaga Park

Approximately 90-95% of the park's useful areas are covered with turf which would obviously suffer severely from irrigation loss. Anticipated loss of landscape value would match the 30, 65 and 100% curtailment levels.

Most of the balance of the park is comprised of indigenous tree species. These forested areas surround the turf areas and predate intensive use of the park. These areas should not suffer significantly in the absence of irrigation.

The park has very little area devoted to shrub cover and virtually no intensively planted area. Therefore, water curtailment is not expected to have any appreciable value loss associated with water curtailment.

De Laveaga Golf Course

Many of the perimeter areas of the golf course are lined with old Monterey pines. These trees are of the age that would render them highly susceptible to pine bark beetle and turpentine beetle. They would be badly affected by any significant loss of water.

During a drought, most golf courses shut down the perimeters of the golf holes leaving the middle of the green watered as long as possible. Such action would have a devastating effect on the Monterey pines at the perimeters of the greens and fairways.

Monterey cypress on the property are very old and would probably not suffer significantly from a change in water availability in the short term, but over the long term, they would begin to fail as well.

The old established trees within the course are either Monterey pines or Tasmanian blue gum. The Tasmanian blue gum would certainly become more badly affected by the lerp psyllid and potentially by eucalyptus longhorn borer as water is removed.

A prolonged drought would cause the inception of a longhorn borer infestation which would in the long term devastate the groves.

Once lerp psyllid or longhorn borer became established in the grove they would very difficult to stop, even if water became available at a later date.

Trees planted in the golf course would suffer to varying degrees depending on species.

The sycamore trees on the one hand will benefit from the lack of humidity caused by reduced irrigation and as a result will have less anthracnose but on the other hand would have more sycamore mildew.

The Chinese flame tree will certainly suffer severely but they are only a relatively small part of the whole inventory.

Winklefarm Park

Winklefarm Park, owned and operated by the County, is located off Sequoia Avenue. Most of the park is comprised of turf, most of it tall fescue with an invasion of other grasses.

A number of young trees have been planted in the turf, all red maple, which will certainly suffer severely if irrigation is reduced to any significant degree.

There are planted coast redwood 'Aptos Blue' along the margin which will suffer if adjacent turf irrigation is reduced by 65%.

Commercial/Industrial

Mission Street between King and Downtown Santa Cruz

Much of this commercial area is bordered by established old trees that are relatively drought tolerant such as London plane trees.

Most of those trees shouldn't suffer more than a 20% decline at the most if irrigation water is shut off.

Unfortunately, much of the landscape is comprised of shrubs species which would suffer up to 60% loss in aesthetic value if irrigation water is shut off. Areas like those that are in front of the Mission Inn Motel would probably suffer even more severe losses than that.

Longs Drugs

The landscape in front of Longs Drugs consists of crabapples, large old Chinese elms, and similar species which would suffer a loss of value of approximately 60% if irrigation is shut off.

Bay Street

Just south of Bay Street is a mixture of Monterey pines, coast redwood and Dodonaea which will certainly be damaged by 80% if irrigation water shut off.

Laurel Street

The commercial area is populated by a uniform planting of *Robinia ambiqua* 'Idahoensis' street trees. These street trees have a mixed age distribution because they have been planted over an extended period of time.

If they have been in the ground three years they should not be affected by drought. Younger trees would suffer significant value loss in the absence of irrigation because they have not been fully established to the site.

Old trees in this commercial area include *Magnolia grandiflora* 'Samuel Summer', *Pittosporum undulatum*, and Japanese privet.

Reduction of underground water supply associated with drought conditions will have a greater effect on these than a reduction in irrigation frequency or volume.

DISCUSSION

In some cases, the partial loss of aesthetic value may be easily recoverable if some or all of the accustomed water supply is re-applied. Tall fescue turf may be an example of a landscape feature which will recover from severe drought if that drought is not extended more than one full season.

On the other extreme, Monterey pine trees which have been accustomed to any level of irrigation will react to severe drought by attracting the two native bark beetles (turpentine beetle and five-spined engraver beetle) which commonly kill drought stressed Monterey pines. Even if the level of irrigation that these trees were accustomed to is restored after two seasons, these trees would probably be a total loss.

Other tree species would also become susceptible to bark beetle attack if they were accustomed to irrigation, which has been removed, such as Tasmanian blue gum, river red gum, manna gum, desert gum and sugar gum.

When large trees are killed by bark beetles, it is usually 2-5 years before they are so hazardous that they must be removed, so the actual costs of drought may require several years to become apparent.

Turf

Many of the lawns were old and comprised primarily of weed grasses and broadleaf weeds, and even maintained turf was often comprised of blue grass/rye mixtures which were heavily infested with the weed grass species that are favored by consistently overwet soils.

Since many of the soils in Santa Cruz are primarily sand with little clay, the soil retains very little nitrogen and any rain or irrigation leaches out any nitrogen which may be present.

This leaves turf deficient in nitrogen very quickly, reducing the current (no water curtailment) aesthetic benefit below an ideal standard irrespective of irrigation reduction. For this reason, reduction in aesthetic benefit from the current standard may not be as noticeable as in more frequently fertilized or less frequently irrigated turf in clay soils.

In other words, many sites are currently badly overwatered.

Native Trees

The native oak trees and many drought tolerant exotic species would be favored by a reduction in irrigation, but if individual specimens have become habituated to irrigation over a long period, they could exhibit severe stress symptoms or even death if sudden, complete removal of irrigation were to occur in spring.

Shrubs

The response of most shrubs to sudden removal of irrigation will be predictable based on the genetic drought tolerance of the species, modified by the degree of establishment of the individual specimens and the frequency of irrigation to which they have become accustomed.

As an example, manzanita and grevillea plants will probably improve in condition in most locations with reduction of irrigation water, while Japanese camellia plants may lose foliage and gradually decline.

A number of surveyed front yards appear to not be receiving any irrigation at this time, and would be unaffected by reduction in irrigation water availability.

A generality which seems accurate is that young landscapes in which woody plants have not yet established extensive root systems are entirely dependent on regular, frequent irrigation and will suffer very severe loss of value and even plant death if even 65% of irrigation water is not available. In contrast, old, established landscapes, composed primarily of woody plants with root systems well established may suffer little effect of irrigation reduction, except for species already discussed.

ATTACHMENT A

Census Tract, 1002

House #1 Hubbard Street

The front lawn is tall fescue and should not be as badly affected by drought as the other lawns we've seen.

The balance of the landscape should tolerate a 65% water reduction with a 50% loss in appearance.

House #2 Market Street

This is a corner lot; this lot appears to be 115 feet by 54 feet.

Turf will probably be severely affected but shrubs will probably survive well.

House #3 Hubbard Street

Very nicely done slate stacked wall in the front but zero maintenance on plants.

No effect on landscape from cessation of water use is anticipated.

It would appear that the backyard may be paved for parking.

Census Tract 1001

House #1 Goss Street

Nice older smaller house, narrow front yard lawn composed of weed grasses, and broadleaf weeds.

It is watered however.

Shrubs composed of camellias, Escallonia, whygella and so forth. Apparently irrigated but not heavily.

House #2 Goss Street

A large lawn in front composed primarily of weed grasses and weeds, some large old shrubs/trees, but most of this did not suffer very much from loss of water because it appears it is not receiving much water.

House #3 Goss Street

This is an old home on a huge old lot 80 foot frontage and the depth is certainly far more than 100 feet.

Twenty significant trees. Note that the Monterey pine trees are already infested with turpentine beetle and any change in irrigation would certainly mean their immediate death from pine bark beetle.

Note that in the backyard are two large giant sequoias which are already partly infected by *Botryospheria* and any reduction in their assumed moisture would result in immediate decline.

The majority of trees on this site will be severely affected by elimination of available water except for the coast live oak trees which will probably not be affected at all.

The coast live oaks are the minority tree population here.

House #4 Isbel Road

This is quite a different environment than the properties we have just seen.

200 foot frontage on a triangular lot with a wide face.

Many very large old coast live oaks with many natural coast redwoods, extremely large lots with a very woodsy atmosphere. Unfortunately, the plantings beneath all these naturally drought tolerant plants will certainly suffer from loss of water.

House #5 Isbel Road

Still in the neighborhood of large old coast live oaks, with a fairly full canopy of native oaks and large old purple plums in the front yard. As a result the front yard is fully shaded. The backyard seems less covered.

No lawn is seen in the front yard and only fairly mature rhododendrons and other shrubs with a leaf litter cover.

House #6 Isbel Road

A new modern landscape, tall fescue turf but large square footage of high intensity plant mix landscape maintenance area. The latter will be badly damaged if irrigation is reduced.

Census Tract 1213

House #1 Sequoia Ave.

This is a relatively old and small house on a small lot, approximately 80-foot frontage looks like a similar lot depth. The whole front yard is covered with old *Ceanothus griseus* 'Yankee Point' in

very poor condition, a big old pineapple guava the remainder of the front yard is covered with Himalayan blackberry.

Reduction in irrigation would have no effect here.

House #3 Lillian Street

A moderately maintained front yard, which benefits more from the moderate climate of the site than it does from intensive maintenance.

House #4 Lillian Street

This is a corner lot. Gravel cover beneath a broad range of shrubs and much pavement.

House #5 Benson Street

A new (probably) home, a lot of pavement, a high proportion of lawn, birch trees, not much shrub landscaping. We are presuming the back yard is similar.

This landscape will be badly damaged by irrigation reduction.

Census Tract 1215

House #1 13th Ave.

An old house that has been remodeled and modernized.

New landscaping combined with the old turf in the front, shrub and herbaceous combination.

Assume this similar use in the backyard with perhaps more turf.

This combination will suffer from irrigation reduction.

House #2 13th Street

Pretty carefree uncared for front yard covered with Japanese honeysuckle, one old apple tree in the front, one old coast live in the back.

Very little impact from drought on anything in this garden is anticipated.

House #3 13th Street

This is an old home, one of the few that has not been remodeled in last few years and has several very old trees and very old shrubs on it.

This is a corner lot with a hedge around two sides.

The hedge composed of species that need virtually no care.

An old black cottonwood, an old incense cedar and an old wild plums are the tree cover.

It is appears to me that nothing on this property is irrigated and for that reason loss of irrigation water should have no effect on it.

House #4 12th Street

This specific area is close enough to the ocean that lack of irrigation water would not have any significant effect until we got to the point of no irrigation water available at all.

House #5 12th Street

An older home that has been rebuilt. Little effect of drought on the purple plum seen here until no water is available at all.

The rest of the landscape would not appear to be the sort that would affected by light drought.

House #6 Prospect and 12th Avenue

The old landscape is composed of old well-established shrubs which should be unaffected by irrigation reduction.

Census Tract 1006

House #1 Escalona Street

A fine old house probably from the last century.

A mixed lawn that is being very heavily watered plus *Eugenia* hedge virtually surrounding the front of the house.

This is a garden that has been over watered for many years and some of the plants have become habituated to it. Even a 65% water loss will cause severe loss of plant health.

House #2 Escalona Street

Beautiful old restored home, with very old *Pittosporum eugenioides*, and *Cotoneaster lacteus*, and a straggly pitiful *Albizia* in the front. Plant condition here represents vast overuse of water.

House #3 Escalona Street

Another old house that has been rebuilt into a duplex.

Old landscaping of well-established bottle brush, *Pittosporum undulatum*, blue Pfitzer juniper, *Agapanthus*.

This is type of landscape shrub mix shouldn't be affected significantly by even 65% water conservation reduction but 100% would certainly affect them.

Here is a case where the *Pittosporum undulatum* in the front of the house is currently has symptoms of oak root fungus, probably due to sprinkler irrigation on the trunk.

If that irrigation supply were removed this tree might actually recovery or it might continue to fail.

House #4 Escalona Street

This is mostly a neighborhood that was rebuilt twenty to thirty years ago. A huge front yard mostly of stepped landscaped areas with fruit trees.

Many old rosemary plants and valeriana (*Centranthus ruber*). This front yard might not be affected at all by loss of irrigation water. The apple tree is chlorotic and so it a peach tree. This may be partly due to overwatering and loss of root health and partly due to an alkaline black clay soil.

The severe chlorosis in many of the plants in this lot as compared with adjacent lots indicate that this entire lot may be overwatered and might actually benefit by a reduction of irrigation.

House #5 Escalona Street

The front yard is entirely composed of old *Baccharis* 'Twin Peaks' which are over grown and would certainly be affected by *Baccharis* lace bug if the water were shut off. The *Ceanothus griseus horizontalis* would certainly be affected if water were shut off.

The Chilean mayten trees would certainly be affected if water were turned off and in the extreme might even decline and die.

House #6 Escalona Street

This is another of these houses built on a steep slope with a level backyard.

The front yard is a step old landscape of well established *xylosma,* well established star jasmine and well established purple plums.

I would estimate that there would be very little effect on the *xylosma* when water is shut off.

Census Tract 1005

House #1 Escalona Street

This is a very well maintained home but whose enter front yard slopes steeply to the street.

	Estimated Cost to Take the Action
Action #1	$_____
Action #2	$_____
Action #3	$_____

5C. Please provide a *rough* estimate of the dollar impact, if any, that this 15% water reduction would have on the gross annual revenue of your business. What percentage of total gross annual revenue would this be?

$_____ _____% of total gross annual revenue

5D. In addition to these potential economic impacts, there may be other hardships that this 15% cutback would impose on your business. Using the table below, please mark the type and level of these hardships. (MARK ALL THAT APPLY)

Type of Hardship	*Level of Hardship*				
	None	***Little***	Some	Considerable	Extreme
Health and safety (e.g. unsanitary conditions)					
Aesthetic (e.g. unattractive or dead landscaping)					
Inconvenience (e.g. time or effort spent responding to shortage)					

Other (explain): _____ _____ _____					

5E. Please explain your entries for Question 5D.

6A. If the City were to experience a more severe water shortage and your business were required to reduce its normal water consumption by **25%** for the months of April through October, what actions would you most likely take to achieve this objective? (UP TO 3 RESPONSES)

Note: *These actions are not in addition to those included in your response to Question 5A.* Thus, one or more of your actions in response to this new scenario may duplicate or overlap with your responses to question 5A.

1. _____

2. _____

3. _____

6B. How much direct cost do you think your business would incur to take each action described in question 6A above? (Note that some actions may not result in any direct cost.)

	Estimated Cost to Take the Action
Action #1	$_____
Action #2	$_____
Action #3	$_____

6C. Please provide a *rough* estimate of the dollar impact, if any, that this 25% water reduction would have on the gross annual revenue of your business. What percentage of total gross annual revenue would this be?

$_____ _____% of total gross annual revenue

6D. In addition to these potential economic impacts, there may be other hardships that this 25% cutback would impose on your business. Using the table below, please mark the type and level of these hardships. (MARK ALL THAT APPLY)

Type of Hardship	*Level of Hardship*				
	None	Little	Some	Considerable	Extreme
Health and safety (e.g. unsanitary conditions)					
Aesthetic (e.g. unattractive or dead landscaping)					
Inconvenience (e.g. time or effort spent responding to shortage)					
Other (explain): _____ _____ _____					

6E. Please explain your entries for Question 6D.

7A. Finally, if the City were to experience a critical water shortage and your business were required to reduce its normal water use by **35% for the months of April through October**, what actions would you most likely take to achieve this objective? (UP TO 3 RESPONSES)

Note: *These actions are not in addition to those included in your response to Questions 5A and 6A.* Thus, one or more of your actions in response to this new scenario may duplicate or overlap with your responses to questions 5A and 6A.

1. _____

2. _____

3. _____

7B. How much direct cost do you think your business would incur to take each action described in question 6A above? (Note that some actions may not result in any direct cost.)

	Estimated Cost to Take the Action
Action #1	$_____
Action #2	$_____
Action #3	$_____

7C. Please provide a *rough* estimate of the dollar impact, if any, that this 35% water reduction would have on the gross annual revenue of your business. What percentage of total gross annual revenue would this be?

$_____ _____% of total gross annual revenue

7D. In addition to these potential economic impacts, there may be other hardships that this 35% cutback would impose on your business. Using the table below, please mark the type and level of these hardships. (MARK ALL THAT APPLY)

Type of Hardship	*Level of Hardship*				
	None	***Little***	Some	Considerable	Extreme
Health and safety (e.g. unsanitary conditions)					
Aesthetic (e.g. unattractive or dead landscaping)					
Inconvenience (e.g. time or effort spent responding to shortage)					
Other (explain): _____ _____ _____					

7E. Please explain your entries for Question 7D.

8. Use the space below and/or attach another sheet to provide any additional comments on the impacts of drought-related water use reductions on your business operation. Consider, for example, possible impacts on production, employment, income and cash flow, expansion plans, or relocation, as well as any other impacts you consider important.

Thank you again for your time.