Greywater Recycling in Santa Clara County

A Quantitative Study and Financial Analysis

Submitted by:
Krey Price
Environmental Water Resources

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EXECUTIVE SUMMARY:

Introduction

Like many areas of California, Santa Clara County is under pressure to reduce water use and wastewater discharge in the face of increasing demand. Under this pressure, a $140,000,000 pipeline system is proposed to reduce the wastewater discharge into the South Bay. This report presents greywater recycling as a water conservation alternative for Santa Clara County. Though technically first legalized in California in 1994, greywater recycling—the practice of filtering wastewater from showers, laundry, and sinks on-site, and applying it as irrigation water—has historically been used in drought years to curb water shortages and preserve landscaping. Despite the enormous potential for water conservation, greywater recycling has not yet received widespread application or publicity. It was ignored in the study for effluent reduction alternatives in Santa Clara County because its potential contribution was thought to be insignificant. This report quantifies the value of the potential water conservation from greywater recycling for Santa Clara County and examines the potential of a rebate program that might encourage implementation of greywater recycling systems.

Findings

Greywater systems can reduce the incoming water supply and the outgoing wastewater discharge by about half. A homeowner benefits from greywater systems by paying lower water bills. A further benefit is that greywater systems can legally be used during irrigation moratoriums imposed by communities facing droughts; this can save valuable landscaping that would otherwise be lost. A community that supports greywater recycling will benefit through lower water demand and reduced discharge to the wastewater treatment plant. Disadvantages of greywater systems as compared to other water conservation measures include relatively high costs and additional maintenance and effort. The feasible water savings through greywater recycling in an existing community are on a smaller scale than those from public works projects such as the reclaimed wastewater pipeline proposed for Santa Clara County. The most commonly heard argument against greywater systems is the potential for health problems. For greywater systems to be safe, they must obviously be used responsibly; the health concerns appear, however, to be primarily a result of a lack of education and research on the subject.

On an average house in Santa Clara County, a greywater system could save about 160 gallons per day. If each new single-family home constructed in the area of Santa Clara County serviced by the SJ/SC WPCP over the next twenty years (estimated at 1,400 homes per year) were constructed with greywater recycling systems, the total water savings and wastewater reduction would be almost 5 million gallons per day (mgd) by the end of the study period. For consideration in the altenatives study in Santa Clara County, a minimum savings of 5 mgd is required. Greywater recycling alone, even in a best-case scenario, would fall just short of this minimum. The combined effect of greywater systems with public education and other efforts, however, could raise the potential above the minimum and should be examined in the diversion alternative study. As outlined in this report, a homeowner installing a $2,000 greywater irrigation system will almost double the investment through lower water bills over twenty years, as long as increases in water rates are taken into account. Landscaping saved in a drought-related moratorium on irrigation can also be seen as a benefit and could potentially increase the benefit:cost ratio to around 4, indicating a very wise investment.

Benefits of greywater recycling to water suppliers and wastewater treatment facilities are much more complex to determine. The preliminary financial analysis in this report, however, indicates that these agencies would not save enough money through lower treatment costs to justify expending funds for a rebate program. The total savings are estimated at $500,000, which averages out to only about $17 per home. If the plant had to be expanded or a new plant built because of increasing discharges, these greywater systems considered in this report could collectively have the effect of lowering the construction costs significantly through a lower design capacity. If the need for the reclaimed wastewater pipeline could be eliminated due to lower discharges through conservation efforts, financing greywater systems would pay off. As a rough estimate, the city is willing to pay $140,000,000 to reduce the effluent by 20 mgd. Considering that each greywater system represents a savings of 160 gpd, this is the equivalent of about $1,100 for each greywater system—enough to cover the additional cost of an average automated system.

Recommendations

A rebate program financed by the water district and awarded through the sewer bills is recommended. The amount of the recommended rebate would fall somewhere between the amount that the wastewater treatment plant would save through the lowered discharge and the per volume amount that is currently spent on conservation efforts. It would amount to about a $50 per year sewer bill reduction for a home on a quarter acre plot. It is also recommended that permit costs be lowered to increase the financial incentive. Despite some of the disadvantages of greywater recycling, the SJ/SC WPCP and the Santa Clara Valley Water District (SCVWD) could ultimately benefit from subsidizing greywater systems through rebate programs. Future water conservation studies in the area should consider greywater recycling as a legitimate alternative. The results of this study are believed to apply to any community in an arid region, although each should be examined on a case by case basis.

Greywater Recycling in Santa Clara County:

A Quantitative Study and Financial Analysis

By Krey H. Price

ABSTRACT: California legalized greywater recycling systems for residential use in 1994. By reusing greywater, homeowners can now reduce their water demand as well as their wastewater discharge. Greywater systems come with their share of limitations, however, which only make them safe and economical under certain conditions. This report will examine these conditions and take Santa Clara County as a case study to determine the financial feasibility of installing greywater systems. The study will be based both from the perspective of an individual homeowner and of a water agency which might benefit from subsidizing the homeowner's cost in large-scale implementation of greywater recycling systems.

SECTION I. INTRODUCTION

This section summarizes the local water shortage problem and presents greywater reuse as a possible solution for Santa Clara County.

California's Water Shortage: When natural resources are threatened, recycling makes sense. Most people probably would not think of water as recyclable, but as the most valuable natural resource in arid Western states such as California, recycling water is necessary for the limited supply to serve the increasing demand. The philosophy of greywater recycling is based on the following question: why irrigate with potable water, when better than half the water that goes down the drain is of high enough quality to use in irrigation? Besides, most elements added to water in the home are, in fact, plant nutrients (Ludwig 1.) California has suffered major droughts in the past, the most recent being from 1976-77 and 1987-92; tremendous effort was put into alleviating the water shortage during these times. In 1990, California experienced a water shortfall of almost three million acre-feet (DWR, 10), which was reflected in mandatory urban water conservation (rationing). Water conservation efforts have only recently managed to slow the increase in water demand, which is due to the large population growth (DWR, 143.) Even with extensive water conservation, urban demand is expected to increase by over 50% by the year 2020 (DWR, 8.) To reduce the shortages, water is piped over great distances for redistribution and vigorous water conservation campaigns are promoted. Nonetheless, in many cases communities still find themselves forced to resort to moratoriums on irrigation, which in peak summer months consumes over half of the residential water use.

Water Conservation through Greywater Recycling: In drought periods, innovative homeowners not willing to watch their landscaping wither away for the sake of a moratorium, often apply *greywater* to their plants. Although for many years this practice was technically illegal, pressurized drip line greywater systems are now allowed in California under the State Plumbing Code (California Plumbing Code Appendix G.) The Uniform Plumbing Code presently allows greywater recycling, also covered in Appendix G, but only in the form of mini leach fields. Water recycling in general is covered under the Water Recycling Act of 1991 (AB 673) and in Water Code Section 13577. The Department of Water Resources now lists greywater use as a potential Best Management Practice for urban water use (DWR, 157.) The State Water Resources Control Board has found that California's large arid and semi-arid regions, the occurrence of droughts, and the presence of large areas of irrigated residential area make this state "particularly suited to the exterior residential use of greywater on a year-round basis" (Ingham, 5.)

Studies have shown that around 50% of the water used in the home could be reused on the property as irrigation water. This is accomplished by plumbing individual homes so that greywater from tubs, bathroom and laundry sinks, and wash machines is collected and filtered, then applied as subsurface irrigation on gardens and lawn areas. Diagrams of both a mini leach field system and a subsurface drip system can be found in Figure A-4 in the appendix.

Several California communities, such as Santa Barbara, have led the industry in adopting greywater laws and promoting greywater reuse. In the Bay Area, the City of Marin has probably been the leader. 8% of the residents currently have some sort of permanent fixtures for recycling greywater, and during one drought, 43% of the residents were using greywater (Ingham, 21.) Despite these advances, greywater reuse has not yet been implemented on a wide enough scale to catch the attention of many of the agencies that are currently searching for water conservation methods to pull California through its next drought. Larger cities such as San Jose remain skeptical; among the half million households in Santa Clara County, only around 200 greywater systems are currently in place, most of which have been installed in the last six years (Bilson.)

Santa Clara County as a Study Area: Many Bay Area communities have been looking into recycling water as high water demand and low water supply drive up the prices. The increasing populations, especially in the South Bay area, threaten to make the effects of the next drought harsher than ever. The Association of Bay Area Governments (ABAG) expects San Jose to lead the Bay Area region in increased population and households over the next twenty years (ABAG, 252.) San Jose makes up most of the population of Santa Clara County, and, like most other California counties, is currently examining water conservation options. The following figure shows the location of the study area with respect to the San Francisco Bay.

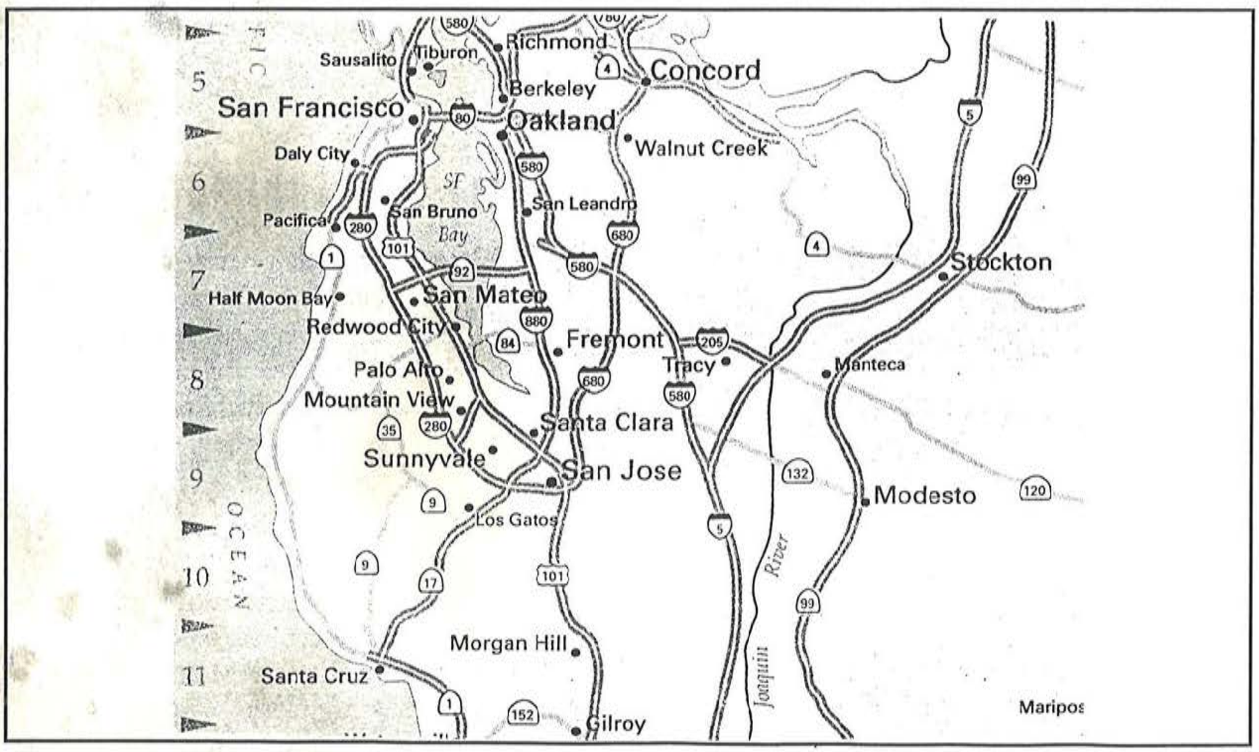


Figure 1: Study Area.

California communities have consistently been under pressure to reduce water demand and wastewater discharge. Santa Clara County is depending more and more on imported water (SCCSVSC, 185), so the county is looking toward recycling options to prepare for the predicted shortfall of 220,000 af/yr by 2020 (USBR "EIS", 1-1.) Several options are available to the county to reduce this dependence and comply with regulations, the most widespread option currently being the use of reclaimed wastewater. A 1973 report of water resources in Santa Clara County lists reuse of water as basically "nonexistent" (Johnson, VII-2.) Water reuse has now increased to about 450 acre-feet per year (af/yr), thanks to the City of Santa Clara's Water Reclamation Program (WateReuse, D-2.) The San Jose/Santa Clara Water Pollution Control Plant (SJ/SC WPCP), which services most of Santa Clara County, is undertaking the largest reclaimed wastewater plan in the region, and one of the largest in the entire state. Under the plan, almost 30,000 af/yr of water will be reused, primarily for irrigation. There has been much concern recently about how this reclaimed wastewater will affect the groundwater quality in the area, but the opposing voice has not prevented approval of many major water reclamation projects (SCCSVSC, 79.)

Wastewater discharge into the South Bay has steadily increased with the growing population of Santa Clara County. As the demand on the treatment plant grew with the population, the plant made plans to prevent the discharge from reaching its 167 million gallon per day (mgd) capacity. These wastewater reduction programs were fairly effective in slowing the increase in discharge, at least to the point where it was thought that the plant would not need expansion by the end of the decade. Recently, however, concerns over the habitats of endangered species in the South Bay salt marshes has led to studies showing that the chlorine-laden freshwater discharges from the plant have actually destroyed the habitats, and that increased discharges would further endanger the wildlife of the area. Opponents of this viewpoint believe that the present discharges are critical in flushing pollutants out of the area and are also necessary to maintain the local striped bass populations (SCCSVSC, 167.) After much debate, the plan is to go forward with the option of reducing the effluent. Under these environmental pressures, the plant has therefore been mandated to cap the discharge into the Bay at 120 mgd under NPDES permit order WQ 90-5 (CRWQCB, 4.)

Several solutions were proposed, including moving the outlet structure to another location, but it has been decided that the most feasible option is to pipe a portion of the tertiary treated water to another location for subsequent use as irrigation water. Under the South Bay Water Recycling (SBWR) program, a $140,000,000 pipeline system to recycle 20 mgd of the current 120 mgd discharge is proposed for construction in 1997. This is a tremendous investment geared toward reducing wastewater discharge, which makes Santa Clara County an ideal study area for researching water conservation alternatives. The City of San Jose's Capital Improvement Program is developing plans to expand the SBWR program beyond the initial 20 mgd diversion. Stakeholders have identified Phase II alternatives, such as water conservation through installation of ultra low-flush toilets, and environmental enhancement, such as wetlands acquisition. These alternatives need to have the effect, either individually or collectively, of protecting the South Bay environment.

The diversion alternative search ignored greywater systems as an alternative, since their potential contribution was thought to be insignificant (Rosenblum.) This study will examine the potential of greywater reuse as an alternative to these options. The study area will thus be limited to Santa Clara County, and more particularly, that area of Santa Clara County serviced by the San Jose Water Pollution Control Plant. The treatment plant services only 8 of the 15 municipalities in the county, but these 8 municipalities include 76% of the county population and 75% of the vacant land (ABAG.) A list of these communities and a map of the area can be found in Figure A-1 in the appendix. The remaining 7 communities are serviced by the Palo Alto and Sunnyvale treatment plants, whose combined discharge amounts to only 35% of the SJ/SC WPCP discharge (SCCSVSC, 166.) Any wastewater reduction option in the study area should first focus on residential use, which accounts for over 60% of the total flow to the SJ/SC WPCP (USBR "EIS', 2-6.)

Water is fairly expensive in the area and wastewater discharge is limited, which, combined with the predictions of increasing population and new home construction, makes greywater systems more feasible in the area. To determine whether a significant amount of water could be saved through greywater recycling, several factors must be considered. This project will examine the extent of new development to determine where greywater recycling would be most beneficial. The projected water demands will be compiled with the associated potential water savings. These savings will be presented both quantitatively and financially. Water quality and groundwater pollution will be discussed but not thoroughly examined in this study. The time frame will be limited to the next twenty years, and results will be based on two perspectives: First, the individual homeowner looking at investing in a greywater system in this area, and second, the government agencies that would benefit from large-scale water conservation and waste water discharge reduction.

SECTION II: GREYWATER RECYCLING

This section defines greywater and lists the benefits and costs of greywater recycling along with the current limitations.

DEFINITION.

What is Greywater? The technical definition of greywater is any wastewater that does not include toilet or kitchen waste. Greywater recycling is putting this water to some beneficial on-site use, usually irrigation. It must be distinguished from reclaimed wastewater, which is water that is reused after discharge into the city sewer system and subsequent tertiary treatment. Greywater recycling could be anything from the conscientious resident who takes a bucket into the shower and later dumps it on a tree to an automated system that filters the greywater and distributes it as irrigation water. Greywater systems can be connected to bathroom and laundry sinks, showers, tubs, and washing machines, but kitchen water should be avoided, due to its high pollutant concentration. Although people have "schlepped greywater around in buckets since time immemorial," automated systems have only recently been offered commercially (Ludwig, ii.) In California, greywater can be broken down to 63% from showers, bathtubs & sinks and 37% for clothes washer (DWR, OWC, 3.)

POTENTIAL SAVINGS.

Greywater Generation and Savings Potential: Landscapes can use up to 50% of the total home water use during the peak irrigation season (Kourik, 6; Sciutto and Zamost, 3; DWR, 153.) Depending on the home's plumbing and the quantity of landscape to be irrigated, the amount of the greywater produced that can actually be recycled varies from case to case. Estimates of the amount of greywater a person generates vary significantly between studies, as shown in the following table as a percentage of total use and also in gallons per capita per day (gpcd.) These values may be overestimates of what is practically achievable—they estimate maximum potential, whereas the actual metered savings may be lower, depending on resident participation.

Table 1: Greywater Generation Estimates.

Source	*Greywater (% of Total Water Use)*	*Greywater Generation (gpcd)*	
City of L.A. Pilot Study	50		(qtd. in Kull, 14)
Bilson	50	50	
Brittain, DeCook, & Foster	30	31 *	(qtd. in Sun, 2)
Brisbane/California DWR	61		
California DWR		40	(3)
Siegrist		29	(qtd. in Sun, 6)
Hirano and Young	40		(1)
Ingham		59 **	(qtd. in Sun 7)
Freifelder	30	50	(20)
Ludwig	80	20-40	(1, 5)

* Figures for Tucson.
** Figures for California.

In a single-family home with considerable landscaping, the residents may not produce enough greywater to satisfy all the landscaping, so that the greywater reuse would merely supplement the irrigation requirements. In arid states such as California, however, homes tend to have very little landscaping, so that a greywater system on a fully plumbed home could irrigate a substantial percentage.

The potential for greywater use is less in areas with higher residential population densities that have less vegetation. The potential also depends on the ability of the soil to absorb irrigation water, since one of the limitations of greywater use is that ponding must be prevented. A ballpark figure for the soil absorption potential is about one gallon of greywater per day for every 40 square feet of soil (Kourik 21.) Another source estimates that each square foot could use a half gallon per week (Farallones, 1.) Sandy soils have a higher capacity, while clays have a lower capacity. More accurate figures for various soils are listed in the Uniform Plumbing Code. The Department of Water Resources' *Graywater Guide* gives a formula (see Table A-5 in the appendix) to calculate the square footage possible for irrigation.

Waste water discharge can vary from 50 to 150 gpcd (Asano, Smith and Tchobanoglous, qtd. in Sun, 6) and would be reduced by the same factor as the incoming water supply if a greywater system were in place. This study will assume a greywater production of 40 gpcd, all of which, according to the preceding criteria, has the potential to be reused as irrigation water on a standard residential plot.

COSTS OF GREYWATER SYSTEMS.

Available Systems: A list of available systems along with their respective costs can be found in the DWR's *Graywater Guide*, Art Ludwig's *Oasis*, and other publications (Prillwitz and Farwell, 15; Ludwig, 12; Kull, 11; Ingham 25.) Kull (44) and Ludwig (43) also list suppliers, many of whom also advertise on various greywater homepages on the internet. The costs range from a few hundred dollars for low-end, owner-installed systems to $5000 for fully automated, professionally installed systems. For the purposes of this study, the greywater systems would be installed before purchase of the home, so a typical mid-range, professionally installed system is assumed. The system would consist of a storage or surge tank, a filtering mechanism, valves, backflow preventers, a sump pump, various electronic controls, and the irrigation system, which would include emitters and supply lines. A diagram showing possible systems can be found in Figure A-3 in the appendix. The cost will be assumed as $2000 for the system and installation. The tabulated costs of greywater systems can include the irrigation system as well. In considering the system costs for this study, however, only the cost above and beyond that of a conventional home will be used. In other words, an irrigation system will be needed whether or not a greywater system is installed, so only the additional cost for the tank and other plumbing fixtures will be considered. This amounts to about half of the total cost. So the additional cost of initial installation of the $2,000 system is actually $1,000, since an irrigation system is included in the assumed cost of each home (Bilson.)

Maintenance costs can vary as much as the system costs. The most predictable maintenance costs come from routine cleaning or replacement of the filters, which a responsible homeowner can generally take care of individually. The average life of a system is not really known, since most manufacturers are still new to the industry, and their systems have not been in place long enough to determine their average life. Among the mechanical equipment in a greywater system, the pumps, especially submersed pumps, will probably require replacement first. Irrigation valves can also clog, and it is possible for the soil to become saturated with the residues, which would require replacing some of the topsoil and replanting the landscaping. In extreme cases, where the soils consist of heavy clays, tests have shown that this could occur as quickly as 7 years (Siegrist.) A more accurate figure, however, is 15-20 years for moderate clays and even longer for sandy soils. Various sources estimate total maintenance costs from $25 to $80 per year (Hirano and Young, 30.)

Some of the more complex systems can also have higher maintenance costs, and the annual dollar savings actually decrease with increasing system cost as shown by the graphic in Figure A-3. This decrease is due to higher monthly payments on the investment while the water savings remain essentially the same. High water users obviously have the most to gain from greywater recycling. For this study, an average system will be chosen with an installation cost of $1000 (not including the cost of the actual irrigation system beyond the price of a standard system.) Maintenance costs will be taken as $50/yr, and the system with the landscaping will be assumed to have a life of 20 years.

LIMITATIONS OF GREYWATER RECYCLING.

Water Quality: Potential health hazards are the most commonly heard argument against greywater systems. Although some systems result in frequent clogging or create odors, a system can be operated safely, cleanly, and efficiently with proper education and maintenance. A detailed explanation of the water quality limitations is beyond the scope of this study, but several of these factors will be mentioned briefly. The proximity to the groundwater table and the permeability of the soil must be considered to determine whether groundwater contamination is possible. Saturated soils, high bedrock, and properties with extreme slopes should be avoided to prevent possible ponding and stagnation of the water. Only detergents and soaps that do not harm the landscaping should be used, but even so, not all plants like greywater, due to the slightly elevated salt levels (Kourik, 21.) The Department of Health Services recommends washing any edible plants grown with greywater irrigation (DHS, 1.) Although greywater use has been approved on a statewide level, city ordinances passed after the state law may take precedence. Sun found that there may be "some risk associated with gray water use when pathogenic bacteria are present in gray water," but that the water met state standards for "irrigation purposes" (Sun 50.) The issue has been studied intensely, but no case of health problems due to greywater recycling has been documented.

Financial: Installing a greywater system into an existing home is possible, and, in fact, can save more water than in a new home, since older homes generally do not have the water-saving fixtures that new homes have. Retrofits are possible, although only for raised foundation homes. Retrofitting an existing plumbing system, however, requires cumbersome work, and often does not pay off financially. In a new home, installation of a greywater recycling system is relatively simple, as long as it is installed at the same time as the plumbing system. Widespread installation of greywater systems is most feasible for new construction. For this study, therefore, only new homes will be considered potential candidates for greywater systems. The feasibility of retrofitting should be covered on a case by case basis. A greywater system will obviously also only be beneficial if the landscaping requires a significant amount of irrigation water. Unfortunately, greywater presents a potential health hazard when sprayed, so application on lawns through sprinklers is not allowed.

Regulatory Issues and Other Considerations: Historically, many communities have limited the use of greywater to times of drought, but due to California's new law, they can now be installed anytime. Greywater use is also generally limited to residential areas. There is a great deal of water saving potential in commercial and industrial facilities such as hotels, laundromats, car washes, and other facilities that generate large amounts of greywater. The focus of this study, however, will remain residential, since this is the only currently approved area statewide. Although there is also a great potential for saving water in apartment complexes, this study will be limited to single-family homes. It must be noted that generalized results of studies such as these are just that: generalizations. Water costs, for example, can vary by up to two orders of magnitude in different areas (Freifelder, 20), so each decision should be based on an individual case study with site-specific conditions.

SECTION III: CONDITIONS IN SANTA CLARA COUNTY

This section covers new home construction in Santa Clara County and examines the current local trends for water use and wastewater discharge.

HOUSING PROJECTIONS.

Location of New Development: Most of the new homes in Santa Clara County will be built in the vacant lands in the incorporated areas zoned for residential use. The areas of Santa Clara County with the greatest amount of vacant land can be seen in Figure A-7 in the appendix. It can be seen that most of the vacant residential land in Santa Clara County is in the City of San Jose, especially on the east side. The San Jose Municipal Water System predicts much of this area to grow by over 100% (Nasser.) Even the developed areas, however, are expected to grow, since current development is built out to just 70% of the zoned density (SCVMG, 7.) Growth in unincorporated areas can be ignored for the sake of this study, since very few homes are expected to be built in these areas. In recent years, for example, only about fifty building permits per year were issued for the entire unincorporated portion of Santa Clara County (Ball.) By far the majority of these permits were issued for the North Valley area, which includes San Jose.

Extent of New Construction: Santa Clara County currently has just over 10,000 acres of vacant land zoned for residential use (SCVMG, 4.) The Santa Clara Valley Manufacturers Group has found that the area could support 69,000 new homes at the countywide average of 7.5 units per acre (SCVMG, 4.) The target homes are those single-family homes with sufficient landscaping to use all of the greywater produced. Many of the new homes to be built are actually in multi-unit housing structures, and therefore would not be included in this study. In the City of San Jose, for example, the vacant land is zoned so that 80% of the potential dwelling units would be on 30% of the vacant land (Parada.) Only 20% of the potential new dwelling units are in areas zoned for five or less dwelling units per acre, although this accounts for the other 70% of the actual land. It is estimated that 10,000 homes per year would need to be built in the county to keep up with the population demand, (SCVMG, 8) but the county currently issues only about 5,000 building permits each year (SCCPO, E-9.) About 40% of the units recently built are single family units, (SCCSVSC, 45) which are the target homes suitable for greywater systems. The following table shows a breakdown of the ABAG forecasts through the year 2015 for the cities contributing to the SJ/SC WPCP.

Table 2: Population and Household Forecasts for Study Area.

ABAG Population and Housing Forecasts Areas serviced by San Jose waste water treatment plant				
Area	Population Increase	Household Increase	% Change	New Homes
Campbell	2,400	1,760	10	704
Cupertino	3,500	1,500	8	600
Los Gatos	600	450	3	180
Milpitas	6,700	2,300	14	920
Monte Sereno	-50	40	3	16
San Jose	160,100	53,230	19	21,292
Santa Clara	19,300	8,730	24	3,492
Saratoga	400	470	4	188
Remainder	1,700	690	14	276
Total	**194,650**	**69,170**		**27,668**

The total number of expected new homes with potential for greywater systems will be taken as 28,000 over the next 20 years, or 1,400 new homes per year. The current household density for Santa Clara County is approximately 3 persons per household (ABAG, 264.) However, for family households, the density increases to almost 4 persons per household, so that these homes would accommodate about 112,000 residents (U.S. Census Report, 3.)

WATER QUALITY AND OTHER FACTORS.

Locations of Sensitive Aquifers: The groundwater table in any location chosen for large-scale use of greywater systems should be checked for sensitivity to contamination. Figure A-9 in the appendix shows the locations of the sensitive areas in Santa Clara County. These take into account the elevation of the water table, the permeability of the soil, current groundwater contamination, and the soil's natural ability to treat percolating water. Soil infiltration figures should be checked, and these can be found in Santa Clara County's *Water Resources Report* (Johnson, 4.) The soils in Santa Clara County generally have low permeabilities (USBR "EIS', 3-18), but the aquitard has some lapses where any contaminate percolation should be avoided (SCCSVSC, 72.) Local water district engineers feel that greywater systems in these areas would need to be controlled more strictly due to the potential of increased salinity in the groundwater. This might be a factor in the area directly bordering the Bay, as shown in Figure A.9. The reader is referred to David Keith Todd Engineers' *Groundwater Conditions in Santa Clara County* for groundwater elevations and aquifer cross-sections.

WATER USE AND WASTEWATER DISCHARGE.

Current Water Use: California's per capita average residential water consumption is over twice the national average (SWRCB, 3.) Daily urban water use statewide averages about 200 gallons per person, 60% of which is residential use (DWR, 152.) On a more regional basis, Bay Area residents use approximately 122 gpcd for residential use, almost half of which is for irrigation (SWRCB, 3.) Santa Clara County will have similar statistics, but the actual use will vary, depending on the type and size of the home. Naturally those homes with more irrigated land will have a higher per capita water use. The average single-family residential water use in San Jose is about 600 gpd in the summer and 450 gpd in the winter (DWR, 148.) The per capita pre-drought rate was about 160 gpcd, which was lowered to about 140 gpcd during the 1987-92 drought (DWR, 151.) For this study, a use of 160 gpcd will be assumed. Single-family homes would generally have higher than average demands, but since the homes under consideration are newly built, they will come with low-flush toilets and low-flow showerheads, so that the actual per capita use in a new development might even be slightly below average. Irrigation requirements will be similar to those in the East Bay Municipal Utility District (EBMUD), where the range is 64 gallons per household per day (gphhd) for off-peak months to 127 gphhd for peak months (Kull, 7.)

Projected Water Use: Water use is difficult to project, but California's Department of Water Resources has estimated that the per capita residential water use will decrease by 4% from 1990-2000, and by 2% every ten years thereafter (DWR, 154.) Although total water use is expected to increase, the per capita demand is expected to decrease slightly through water conservation practices and a general increase in conscientiousness.

Current Wastewater Demand: The San Jose Water Pollution Control Plant currently treats 120 mgd (CRWQCB.) For a population of 1,222,000 (ABAG, 262) in the area serviced by the plant, this translates into about 100 gpcd. However, this includes discharges from industrial sources. For average dry weather flows, the per capita flow to the plant is about 65 gpcd (USBR "EIS", 2-6.) The City of San Jose charges according to an average of 240 gallons per living unit per day. For an average household density of 3 persons per household, this amounts to 80 gpcd of wastewater generated, which will be the figure used in this study.

Projected Wastewater Demand: Wastewater discharge to the treatment plant in the study area historically increased by about 3 mgd per year through 1982 (Brown and Caldwell, 3-3.) It is this trend that initially necessitated the cap on discharge and that now brings the problems in complying with the cap. For the next twenty years, however, due to the increased awareness from the South Bay Recycling Program, the per capita discharge will be assumed to decrease at the same rate as the water supply. By the year 2000, it will be taken as 78 gpcd, and by 2010, 76 gpcd. It must be noted that it is the per capita rate that is decreasing—the overall volume of discharge will continue to increase. The following table shows a summary of the water use and wastewater discharge assumptions for this study. The difference between water supply and wastewater discharge would be accounted for by consumptive use. Consumptive use could be from drinking water or leaky pipes, but by far the greatest consumptive water use is irrigation.

Table 3: Water Demands for Santa Clara County Residents in Single-Family Homes.

	Current Use (gpcd)	Projected (2015) (gpcd)	With Greywater Recycling (gpcd)
Water Supply	160	155	120
Wastewater Discharge	80	76	40

Section IV. Potential Water Savings in Santa Clara County

In this section, a financial analysis will be performed to determine the potential savings from greywater systems. The following table summarizes some of the assumptions and other input figures for the analysis.

Table 4: Assumptions for Financial Analysis.

Average cost of new home	$240,000 (SCCSVSC, 8)
Value of landscaping	$20,000 (5 - 10% of home value)
Total number of homes to be built	28,000 over 20 years
Water use per home	560 gallons per day
Greywater recycled per home	160 gallons per day
Cost of water supply	$1.50 per hundred cubic feet
Cost of waste water treatment	Based on lot size / historical use
Cost of greywater system	$2,000
Actual additional cost for system	$1,000
Maint. costs for greywater systems	$50/yr
Life of greywater system	20 years
Commercial Interest rate	7 % annually (ABAG, 18)
Inflation rate	4 % annually
Increase in water rates	8 % annually (SCVWD, 31)
Effective interest rate	3 % annually
Duration of study	20 years

Total Savings for Study Area.

Quantitative Savings: The following calculations are for the case in which 100% of the new homes constructed in the area are built with greywater systems. For 1,400 new homes constructed each year in the study area, each with the potential of recycling 160 gallons per day, the total water savings would start at 224,000 gallons per day and would increase by that amount each year, giving a potential savings of 4.5 mgd by the year 2015. This actual rate would vary, depending on system efficiencies and rainfall. (In a wet year, slightly less greywater would be reused than in a dry year, since rainfall could supplement irrigation.) Although the initial water savings estimated for Santa Clara County is only a fraction of a percent of the total flow, greywater reuse does have the potential to make a significant impact on a community's total water use. As an example, the Marin Municipal Water District conducted a study of the potential water savings from greywater systems. The systems were assumed to be installed in homes with four or more persons per household. With 100% retrofitting, the District found that the savings would be about 1660 acre-feet of water per year (MMWD, 1.) This is a substantial portion of the city's 30,000 acre-feet total water use, and it would cost $1,000-$2,000 per acre-foot of water saved.

Financial Savings to homeowners: The costs and savings will obviously vary from home to home, but for this study, an average new home in the East San Jose area will be chosen (where the highest growth is expected to occur.) The financial analysis will take the perspective of a homeowner looking at buying a new home in this area, with or without a greywater system. To determine the potential savings from the greywater system, the cost of water must be known. The study area is serviced by over a dozen water suppliers, each with their own rate. The San Jose rates will be used here. The San Jose Municipal Water System (SJMWS) has a tiered rate, a portion of which is shown in Table A-4 in the appendix. For this study, the Zone 3 rate from the SJMWS will be chosen as an average $1.50 per hundred cubic feet, plus the meter fee, which for a 2" meter would be about $64 per month. This comes from a family of four in a house on a quarter acre plot using 560 gallons per day (2240 ccf/mo).

As previously found, the total additional cost to the homeowner would be around $1000 for the initial installation plus $50/yr for maintenance costs. One of the main benefits to the homeowner with a greywater system would be lower water bills. The decreased discharge to the wastewater treatment plant cannot be seen as a benefit to the homeowner under present policy, however, since sewer rates in this area are currently based on the size of the plot and historical average discharges. Energy costs for operating greywater systems depend on the local cost of energy as well as the relative elevations of the storage tanks and the yard. These expenses are negligible for gravity-driven systems and will be ignored here. It must be noted, however, that in certain fully automated systems, energy costs can become significant, in some cases as high as $0.18 for every $1.00 value of water saved (Kull, 16.)

A homeowner in this area would save an average of $1.50 per hundred cubic feet (ccf) of water saved; the meter charge will be assumed to stay the same, although a smaller meter might be used. So for a greywater system that would save 160 gallons per day, or 7800 cubic feet per year, the total savings would be $117/yr. Subtracting the maintenance costs from the annual savings gives a net savings of $67/yr. At a 3% interest rate (above inflation), $67 per year will not quite pay off a $1000 investment when amortized over twenty years (See appendix for calculations of P/A.)

Two other factors, however, need to be included. The first is the increase in water rates. Wholesale water rates for the Santa Clara Valley Water District have increased at a rate of about 10% per year in recent years (SCVWD, 31.) A portion of this increase, however, has been blamed on the recent drought, so for this study, a rate increase of 8% per year will be assumed, which is still twice the assumed inflation rate. This means that each year, the homeowner will save more money for the same amount of water saved. For a $1,000 initial investment, annual costs of $50/yr, and a profit of $117/yr increasing by 4%/yr, P/A is 14.9 and P/G is 127. The water rate increase will be linearized to 7.5¢/ccf to simplify the calculations, which can be found with a diagram in the appendix. The ratio of the present value of the return to the present value of the investment is about 1.7, indicating that the investment would be profitable if the increased water rates were taken into account. In other words, the investment has paid itself off and generated a 70% profit.

The second factor that should be considered is the value of the landscaping. Historically, the area has suffered two major droughts in the past twenty years that resulted in local moratoriums on irrigation. Less serious droughts occur fairly often, as well. One might expect at least one serious drought and several lesser droughts in the next twenty years as well. The investment into the surrounding landscaping is difficult to quantify, but can be assumed as 5 - 10% of the value of the home. For this study, the lower-end of the range will be taken, so that the cost of the landscaping is assumed to be about $12,000. With the further assumption that during major drought periods, 25% of the value of the landscaping is lost, this represents a $3,000 loss during each drought period. These losses could be prevented by using greywater to irrigate (which is legal even during a moratorium), and the potential loss actually becomes a benefit to the homes that have the system, since it essentially money saved. A drought is by nature unpredictable, however, so the timeline below is just one of a number of possible scenarios.

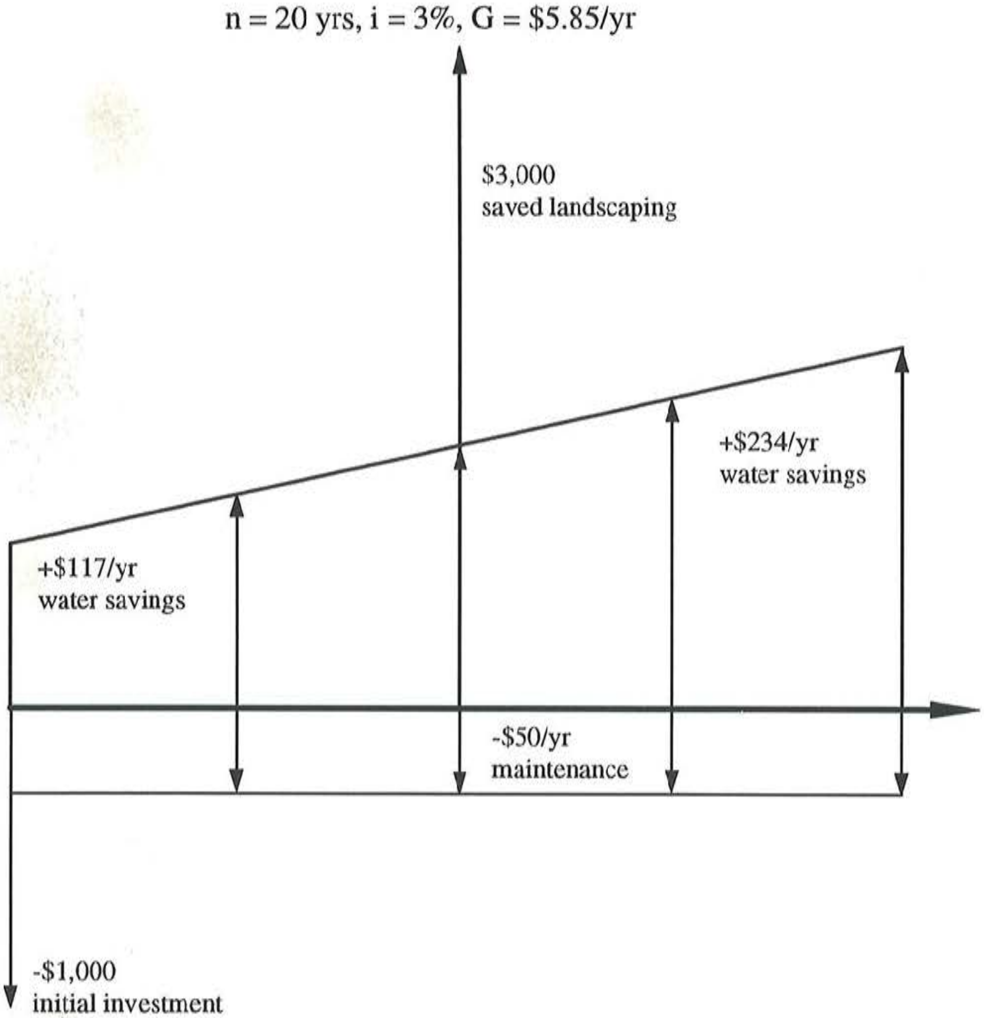


Figure 2: Costs and Benefits to the Homeowner.

Using the formulae:

$$\left(\frac{P}{F}\right)_n^i = \frac{1}{(1+i)^n},$$

$$\left(\frac{P}{A}\right)_n^i = \frac{(1+i)^n - 1}{i(1+i)^n},$$

and

$$\left(\frac{P}{G}\right)_n^i = \frac{(1+i)^n - 1}{i^2(1+i)^n} - \frac{n}{i(1+i)^n},$$

the following values are obtained:

Present value of investment:	P	=	$1,000
Present value of constant annual savings:			
	(P/A, 3%, 20)	=	14.9
(subtract maintenance costs)	P	=	14.9 * $67
	P	=	$ 997
Present value of annual savings gradient:			
	(P/G, 3%, 20)	=	127
	P	=	127 * $5.85
	P	=	$ 742 (from water saved)
Present value of landscaping saved:			
	(P/F, 3%, 10)	=	0. 74
	P	=	0.74 * $3,000
	P	=	$ 2,232 (landscape saved)
Total benefits:	P	=	$ 997 + $ 742 + $ 2,232
	P	=	$ 3,971
Benefit – Cost Ratio:	$3,971 / $1,000		
		=	**4.0**.

The net present value of the investment is around $3,000, and the benefits exceed the costs by a factor of 4, indicating that a greywater system would be a very wise investment if a drought were to strike. This may be a conservative estimate, since for some homes, the landscaping can add upwards of $20,000 to the value of the home. For homes with very expensive landscaping, the results of a major drought could be disastrous without a greywater system.

Financial Savings to Treatment Plant: A complete financial analysis for a water agency would need to include bond rates, state and federal tax rates, eligible/ineligible and fundable/nonfundable cost proportions, and other factors beyond the scope of this report. The figures will be limited to a general cost and savings estimate based on the present value of the investment and the benefits to the San Jose/Santa Clara Water Pollution Control Plant (SJ/SC WPCP.) The treatment process for the SJ/SC WPCP has become much more complex in recent years due to more stringent California Department of Health, EPA and NPDES requirements

(SCCSVSC, 186.) Over the past twenty years, however, advances in treatment technology have actually enabled a 15% annual reduction in treatment costs (SCVWD, 11.)

It must be noted that a reduction in wastewater discharge, will not automatically lower the treatment costs, and the financial benefits do not vary linearly with the quantitative savings. Many factors, such as pumping costs, chemical costs, and staffing requirements must be considered. One might think that treating half as much water would cost half the amount. For pumping costs, this can come close—but the overall cost reduction depends on the portion of the total cost that goes toward pumping. For a 50% reduction in wastewater discharge, for example, overall operation and maintenance costs are reduced by a maximum of only about 3%, according to one study on California (Koyasako, 11.) Wide-scale water conservation can increase the pollutant concentration in the wastewater, which can actually increase the treatment costs for a plant due to the additional chemicals required or clogged sewer lines with insufficient slope. During a drought period where flows in various California municipalities were reduced from 5 - 50% (Koyosako, 12), operational costs of some of the treatment plants increased as shown in Figure A-5 in the appendix. Although some plants experienced these slight cost increases during the periods of low discharges, they experienced no "serious operational problems" due to the change (Koyosako, 2.) The only way greywater systems could result in a similar combined effect is if they were concentrated in a new development. For the case of a new development where a significant number of the homes had greywater recycling systems, the slopes of the sewer lines would need to be increased to account for the higher concentration of the sewage.

A 1982 study found that the SJ/SC WPCP would save about $30,000 annually for each mgd of flow reduction (Brown and Caldwell "1982", 1-3.) This would be equivalent to about $50,000/mgd/yr in 1996 dollars according to the CPI, and even more according to the *Engineering News Record* construction index. For 1,400 homes to be built each year, each saving 160 gpd through greywater systems, the annual savings to the treatment plant would begin at $11,200/yr and increase to $224,000 per year at the end of the twenty year study period. At the 12% interest rate used in the SJ/SC WPCP study, P/G is calculated to be 75, which gives a present value of the savings of $500,000. For 28,000 homes, this becomes about $17 per home, which, when compared to the cost of a greywater system, may not be enough incentive based solely on these treatment costs.

An additional source of savings from automatically-controlled greywater systems is that regulated irrigation prevents overwatering. Overwatering affects more than the consumer's water bill; the treatment plant receives the effluent from excess irrigation water that seeps into the system through leaks. This can become a substantial source of water. In San Ramon, for example, 20% of the summer sewage flow comes from infiltration into the system. The effects of the reduced flows on the incoming flows at the treatment plant would probably not be noticeable, especially if the systems were only installed in new homes. Even with the reduced flows, income for the treatment plant would not change for the SJ/SC WPCP, since only commercial sewer fees are charged based on a unique assessment of the expected volume of discharge or the strength of the sewage discharged. The only way for greywater systems to provide a noticeable reduction in discharge would be if a major retrofitting program were effected. Even if the systems were to make a significant impact on the flows, the SJ/SC WPCP is already in place and operating well below capacity, so reduced flows would not actually save the plant a significant amount of money. In an existing facility operating below capacity, the possible lower treatment costs from reduced flows would probably not justify a large investment into discharge reduction. The following scenarios, however, would make discharge reduction a wise investment:

- A new treatment facility is required
- An existing treatment facility must be expanded
- Other new structures or facilities are needed to reduce effluent

For the first situation, if a city is planning to build a new treatment plant, and greywater systems were to have a significant impact on the expected flow, the facility could be sized for lower flows. California expects to spend over half a billion dollars on new treatment plants in the period 1980-2000 (Koyasako, 41.) Any fraction of this amount saved by building smaller facilities than expected is a major sum of money, and if construction of a new facility can be entirely avoided through reduction of discharge, the savings would be tremendous. Consider the following scenario: A community's current wastewater treatment plant is operating at maximum capacity, and a new plant in a different location is proposed to treat the increased discharge expected over the next several years. If discharge reduction efforts such as greywater recycling eliminate the need for the new plant, the value of the water saved could be quantified. A new wastewater treatment plant can cost up to $5,000,000 per mgd of capacity (City of Cedar

Springs.) If a home can save 160 gpd through greywater recycling, the value of this avoided cost would be $800 per home, which is almost enough to entirely finance the greywater systems.

If a new plant is planned and the expected capacity is lowered, only certain portions of the facility can be reduced in size. Processes accounting for only about 40% of the total facility cost can be reduced for lower flows. Construction cost reductions are only about two thirds of the unit size change, i.e. a 20% lower capacity will give about a 12% reduction in cost (ABAG "Technical Memo", 16.) On an avoided cost basis, If the new plant is sized for lower flows, the budget for chemical costs for the chlorine and sulfur dioxide can be substantially reduced as well. It costs around $800 to send a million gallons of water to a treatment plant in a new facility, so the reduced flow of even 0.2 mgd in the first year of the greywater recycling program for this study could save $60,000 per year (Kull, 15.) This might seem insignificant next to the treatment plant's overall operating budget for a large facility such as the SJ/SC WPCP, but it should still be looked into.

For the second situation, if expansion could be avoided through encouragement and implementation of a greywater recycling program, the return on the investment could also be tremendous. California expects to spend over three quarters of a billion dollars on enlarging treatment plants in the period 1980-2000 (Koyasako, 41.) Greywater recycling on its own, however, could probably not entirely alleviate the need for expansion, especially since there is no guarantee that people would use the systems to their full potential. It would have to be combined with other water conservation measures to have the desired effect. Expanding a treatment plant is often as expensive as building a new one, so the potential savings are similar to those listed in the first situation.

The South Bay Recycling Program is an example of the third situation. The project to reduce the effluent by 20 mgd comes at an unamortized cost of $140,000,000 (not including debt service or O & M costs.) If greywater systems and other conservation measures could reduce the discharge by 20 mgd, it could offset the costs of the SBWR program. One of the primary avoided costs is the pumping cost of the conserved water. If the treatment plant saves about $50,000 per mgd/yr for reduced flow in energy reduction costs, the savings amount to only about 10% of the savings in construction cost found above for the case of reduced capacity in a new plant. Power input required for pumping varies cubically with the discharge (Linsley, 424), so the expended energy can be substantially reduced. Electricity for pumping at the treatment plant accounts for around 30% of the plant's total electric bill (Koyasako, 41.) On a pure flow-reduction basis, the SBWR program will save the treatment plant about $1,000,000/yr, which is annually less than 1% of the cost of the SBWR program. The $140,000,000 price tag for diverting 20 mgd amounts to $7,000,000 per mgd of prevented effluent, even more than for the new treatment plant listed above. For greywater systems saving 160 gallons per day, this would amount to $1,120 per home, more than enough to cover the additional cost of the system.

Financial Savings to the Water Supplier are more difficult to quantify, since most of the benefits are indirect. The water supplier makes its money by selling the water and would therefore not benefit directly from reduced water use. Every water supplier exists to serve the customers, however, and in drought situations, they have failed to meet the customers' needs. For this reason, water suppliers tend to support water reduction programs so as not to have to raise prices to curb demand. This is especially true in California.

COMPARISON WITH OTHER OPTIONS.

Reclaimed wastewater: The effluent reduction from the SBWR program is on a much larger scale than the savings from greywater systems. It must be noted that the bond raised for the SBWR was not meant as an investment to be paid off through conserved water—the net present value of the project is negative—rather, it was meant to comply with environmental regulations. The benefits of this compliance are difficult to quantify, but the "no project" option of non-compliance is not considered as an alternative in this study. Reclaimed water can cost upwards of $1,000/af, which is much higher than the wholesale water price in Santa Clara County (USBR "EIS", 5), so any potential reduction before treatment should be examined. The City of San Jose is actually considering an ordinance that would require two distribution systems in new developments, one with potable water and one with reclaimed water for irrigation and possibly toilet flushing (USBR "EIS", 2-13.) Such an ordinance would probably eliminate or at least significantly reduce the demand for greywater systems in new developments in San Jose.

Other Alternatives: The SBWR program is looking into any options that would have the desired effect of reducing the chemical-laden fresh water discharge into the Bay at Artesian Slough. In order to be considered as an alternative for the program, the options must show the potential of reducing discharges by at least 5-10 mgd. This study shows that even in a best-case scenario, with greywater recycling being vigorously supported, endorsed, and implemented in 100% of the new homes built in the area serviced by the plant, the amount of water saved even after twenty years would fall just short of the desired 5 mgd minimum. If greywater recycling were combined with the other methods listed in the Phase II Alternatives report for the SBWR program, however, the combined effect would be sufficient to meet the minimum required effluent reduction. Implementation and encouragement of water conservation practices now could generate enough savings later to avoid the expected and very expensive structural alternatives for the SBWR program. Among the before-treatment alternatives, greywater recycling is probably the most expensive in terms of money invested per unit of conserved water, but it is also among the longest-lasting. It might be added that on a purely economic basis, homeowners should look into those water conservation options that would save hot water first—the energy costs from heating a gallon of water can be over six times the actual cost of the same volume of water (Brown and Caldwell "1982", 1-3.) Many of these other options, however, have already been attempted or implemented in Santa Clara County. Greywater recycling is thought to be one of the better available alternatives for reducing the total water demand and ought to be considered in the Phase II report.

FEASIBILITY OF REBATE PROGRAM.

Modeling and predicting public response to rebate offers is difficult, especially since many of those who would benefit from the system would be considered "free-riders," who would have installed the systems regardless of the rebate. In one Bay Area rebate program, a study indicated that 65% of those receiving rebates were "free-riders" (Sciutto and Zamost, 6.) This increases the program cost, since most of the money spent on rebates is a reward, but not an incentive. In a benefit – cost study, therefore, only the benefits from systems that are installed as a direct result of the rebate program should be considered against the cost of the rebates. One of the most vigorous rebate programs is in place in San Diego, where residents are offered direct ratio rebates—50% rebate on monthly sewer fees for a 50% flow reduction. In some cases, rebate programs have been implemented without requiring additional staff, but administration and inspection costs have been found to add about 10% to the cost of the rebates, but (Sciutto and Zamost, 7, 23.)

Tax credits are sometimes used as an alternative to rebates, as for the case of installing solar panels in a home. The only water-saving devices that currently qualify for federal and state tax credits are low-flow showerheads, due to their potential energy savings (Brown and Caldwell "1982", 4-11.) Rewriting the tax codes required to implement a tax rebate program for individual homeowners is complicated and should probably not be pursued if the incentives can be offered more easily through another source.

As an alternative to tax credits that might also be considered for greywater systems, PG&E offers 0% loans up to $1,000 for certain energy-saving retrofits (Brown and Caldwell "1982", 4-11.) The experience of commercial companies might be the most effective alternative—they have learned that consumers "respond well to cash offers" (Sciutto and Zamost, 7.) A study for the North Marin Water District's (NMWD) "cash for grass" landscape water conservation rebate program found that connection fee credits, for example, did not offer sufficient incentive for users, whereas their cash offers (which ranged from $50 - $340) were very effective. Developers for the NMWD study, however, responded better to the connection fee credits (Sciutto and Zamost, 5.) Rebates might be targeted at developers, since this is where the greatest potential lies. The program has been in place since 1985 and appears to have accomplished its goals.

Treatment Plant: The State of California encourages water treatment plants to "vigorously implement" water conservation measures (Koyasako, 42) and requires a cost analysis of water conservation measures as a condition for federal funding of treatment plants under the Federal Water Pollution Control Act (PL 92-500.) Greywater systems should therefore be considered as one of the possible water conservation measures in the next cost analysis for the SJ/SC WPCP and any other plant in California. The question as to whether the SJ/SC WPCP should subsidize greywater systems depends on numerous factors, some of which are difficult to quantify. The current sewer rate structure for San Jose, which is based on square footage for larger homes, is shown in Table A.3 in the appendix. This type of rate structure assumes that the discharge to the sewer will increase proportionally with the size of the property, an assumption that generally holds. For this study, it will be assumed that the homes in question are on 1/4 acre plots or greater, so that the combined annual storm and sanitary fee would be $800 per home. The storm fee should not be modified, since runoff from the property would be unaffected by the greywater system. $500 of the $800 is for the sanitary fee. For homes on less than quarter-acre plots, a flat rate of $447 per lot is charged.

I would recommend revising the sewer fees so that homeowners with greywater systems are charged according to the flat rate, regardless of the size of their property. By modifying the classification as opposed to adding a new category for greywater users, the list of sewer fees could remain unchanged. Under this system, the homeowners with the largest properties, who might save the most water through installing a greywater system would benefit the most from the rebate program. On a quarter acre plot, this would save a home-owner about $50 per year. On larger plots, the homeowner would save between $1500 and $2000 per acre. This might seem biased toward homeowners whose properties span several acres and who would otherwise be paying several thousand dollars per year in sewer fees, but a homeowner with a greywater system in place is probably also a very frugal water user, so that even on excessively large plots, the actual discharge to the treatment plant would be no greater than from a standard lot.

If the rebates affect the operating costs significantly so that costs would need to be raised all around to compensate for the rebates, an alternative would be to classify the homes with greywater on a per lot basis for the first year only or to reduce the connection fee instead, so that the cost through lost revenue to the treatment plant is a one-time sum for each home. This would encourage installation of greywater systems in new homes as opposed to retrofits. Switching the classification may not be enough incentive for homeowners, but perhaps the standard rate might be charged and the difference refunded as a cash offer. This would then also benefit homeowners with plots smaller than a quarter acre. The rebate amount could correspond to the percent reduction in discharge vs. financial savings from reduction. For example, the costs of treatment in an existing facility are reduced by about 1% for every 15% in water savings (Koyasako, 11.) For an area considering new facilities, the cost reduction would be much higher—around 10% for every 15% of flow reduction (ABAG "Technical Memo", 16.)

The SJ/SC WPCP has spent considerable amounts of money in the past to reduce flows. The Residential Water Conservation Demonstration Project in 1983, as an example, was an effort to reduce the flows to the SJ/SC WPCP and avoid expansion of the facility. The $700,000 project supplied each home in the service area with a kit of water-saving devices. The discharge to the plant was consequently reduced by 1.5 mgd (Brown and Caldwell, 1983.) $700,000 toward greywater systems, as a comparison, would build about 350 systems, each saving almost two hundred gallons per day, and the overall savings would be about 0.1 mgd, which obviously is not even on the same scale. The cost per mgd saved for the mass mailing is about $500,000. For greywater it would be about $10,000,000 (This could be split between homeowners and agencies through subsidization.) The options now under consideration, such as the SBWR pipeline, are all on the upper end of the scale shown in Figure 3 in the next section. As a rough comparison to the pipeline, the $140,000,000 initial cost to divert 20 mgd puts it on about the same scale as greywater systems in terms of the price of conserved water: about $7,000,000/mgd.

For the treatment plant in this case, the conclusions should not be based on a benefit – cost analysis, but on an avoided cost basis. Due to the mandate, either way, the costs will outweigh the direct financial benefits. But the treatment plant itself is not paying for the pipeline entirely; rather the public will pay through higher taxes and gradual rate increases, meaning that the treatment plant would not receive the full benefit of the saved water. The public, therefore, would need to support any program that is implemented.

Water Supplier: The Santa Clara Valley Water District is the wholesale water supplier for most of the region in question. The district currently provides water at an average price of $310 per acre-foot (SCVWD, 31.) It would be problematic to analyze all of the secondary departments and agencies that each play a role in supplying water to the county. A complete list of these suppliers is shown in Table A.2 in the appendix. The district has a program in place to provide financial assistance toward the water recycling costs of large-scale projects. These proposed projects must replace firm water demands that are currently met or would be met in the future by district supplies (SCVWD, 9.) Greywater recycling, though not a large-scale use, meets this criterion. The district currently offers $75 rebates on low-flush toilets (SCVWD, 10.) An overall financial analysis is fairly complicated due to the difficulty of quantifying some of the benefits for the water district. As a rough comparison to greywater systems on a pure water conservation basis, the low-flush toilet rebate program is assumed to have paid off (as indicated by the program's renewal last year.) 15,000 rebates were given for a total cost of $1.1 million. The resulting water savings from the 15,000 toilets is about 840,000 gallons per day. This corresponds to a cost of $1.3 million per mgd saved. If the district is willing to pay $1.3 million/mgd, and each greywater system saves 160 gallons per day, this would amount to about $200 per greywater system. Other districts in Southern California offer $100 - $150 rebates per acre-foot of water saved in large reclamation projects (Kasselberg.) Again, for an average savings of 160 gpd for each greywater system, this amounts to $20 - $30 per year for each system. This could be converted to a one-time rebate of $200 for the 20-year life of a system.

Any city or agency considering subsidization must determine the least expensive and most effective method of subsidization and must understand the concept illustrated in the following figure, which shows graphically the initial investment required to produce a given % water reduction.

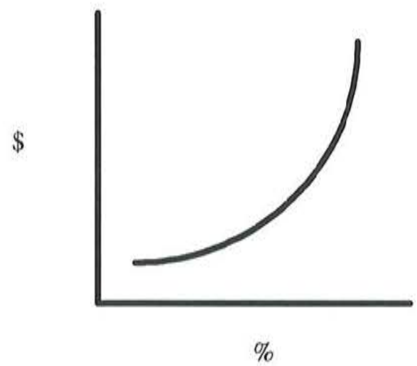


Figure 3: Cost of water conservation as a percentage of water use.

Although further research may produce lower costs, greywater systems currently fall into the high end of the scale. Low-flow shower heads and toilet tank inserts, for example, are on the lower end, since they have a very low initial cost with water savings similar to those that a greywater system would produce. It is therefore best that cities first put their effort into lower cost methods, and that higher cost methods are only recommended when these are already in place. Unfortunately, these inexpensive solutions have already been done in Santa Clara County, so that the next available options are all relatively expensive.

A rebate program might best be operated in coordination with the building permit process, since greywater system installations are currently regulated under building permits. In some cities, the Health Department charges for permits to use greywater and can thereby regulate the use. Austin, Texas is one such example, where $50 fees are charged for percolation tests and preliminary site inspections. Permits cost between $200 and $300 (Christensen.) In some cities, the cost of the permits make it nearly impossible for the greywater system to be economical. Marin, for example, currently considers greywater irrigation systems the same as septic tanks, and charges an $800 fee for the permit. There are many other issues involved in determining the feasibility of a rebate program, which contribute to making it a very complicated problem. If the water supplier (in this case the SCVWD) can quantify its benefits on a per volume rate, financial efforts of subsidization should be coordinated with the water treatment plant. It would be too complicated to have more than one rebate program in place for the homeowner, so the District could assist the treatment plant's lost revenue through lump sum payments that will come to the homeowner in the form of reduced sewer fees.

SECTION V. SUMMARY OF RESULTS AND RECOMMENDATIONS

Greywater systems were shown to by financially feasible and profitable for the individual homeowner interested in contributing to the water cycle. The do-it-yourselfer can get by with a very reasonable investment. For professionally installed systems, the revenues from reduced water bills are not sufficient to pay off the system cost unless rate hikes are considered. The systems are even more economical when the cost of landscaping that would otherwise be lost to drought is considered. The cost per volume of water conserved is very high compared with some other water conservation methods. There are much cheaper ways to conserve water, and greywater systems should only be considered after these other methods have been implemented Other benefits besides saved money include reduced chlorine in the Bay, healthier vegetation and wildlife, and other environmental benefits. Some benefits are harder to quantify, however—the "good feeling," for example, of using less water, leaving more available to others through your own effort (Ludwig, 25.)

In the big picture for Santa Clara County, even if all of the new single-family homes built in the area serviced by the SJ/SC treatment plant over the next twenty years were built with greywater recycling systems included, the resulting water savings would probably be insignificant compared with the South Bay Recycling Program and other larger-scale reclaimed wastewater options. Greywater recycling, however, should be combined with the Phase II alternatives for the project. The combined water savings from these sources would help the plant avoid the excessive costs of building more structures to divert the effluent. A rebate program is proposed to encourage implementation of greywater systems. The current rebate program does not truly reflect the amount of actual discharge, which would be difficult to measure. The proposed rebate program would reward the greywater users (who are discharging less water to the treatment plant—up to half the discharge) by charging greywater users by the standard per lot basis rather than on a per acre basis. This is the equivalent of a $50 annual rebate for a homeowner with a quarter-acre plot.

The only way to obtain the desired magnitude of results is to either vigorously encourage new developers to implement greywater systems in single-family homes with significant landscaping, or to heavily subsidize the systems to encourage people to invest in them themselves.

Results are often better obtained through "customer friendly demand management" programs such as rebates, rather than litigation (Sciutto and Zamost, 4.) Even if it continues to be used only on a smaller scale, however, greywater recycling should be encouraged as a method for individual homeowners to take a conscientious role in helping the city to meet its water demands. Greywater systems would be especially ideal for large new developments, where they could be installed fairly cheaply, and where maintenance could be concentrated. Although cooperation could prove difficult, the treatment plant might work with developers in devising an incentive for greywater reuse. Greywater recycling should be encouraged and publicized by developers as a good investment for environmentally conscious homeowners interested in preserving their landscaping during a drought.

SECTION VI. CONCLUSIONS AND REMARKS

The San Jose/Santa Clara Water Pollution Control Plant and the Santa Clara Valley Water District could benefit from encouragement of a greywater recycling program, even if it meant subsidizing the initial costs of the system through a rebate incentive. Further research is necessary to reduce the costs enough to make the systems affordable to more households, including lower-income homes. Public education about the risks and advantages of greywater use is also encouraged. Large-scale implementation of greywater systems would have a dramatic effect on the quantity of water use. Although figures in this study are specifically from Santa Clara County, the results are believed to apply to any city in arid areas. It can be noted that much of the literature about greywater recycling was produced during or just after major drought periods. It would be very difficult to convince the public and the authorities of the value of this type of preparation during a wet year such as 1996.

Any suggestions for change in an agency that deals with water will almost certainly be met by the opposing comment "it's a lot more complicated than that." One aspect that makes it more complicated is the sometimes opposing missions of the agencies with jurisdiction over water law, distribution, or treatment. Accelerated progress in this area is not possible without inter-organizational cooperation. Surely one of the most prominent objections to greywater use is also the idea that greywater is "psychologically repugnant," as one DWR survey found (SWRCB, 19.) The State Water Resources Control Board found that the "majority of objections to wastewater use are cultural" (SWRCB, 19.) Publicity and public education are therefore very important to the future of the industry.

This study considered only very limited cases. The actual potential for recycling water is much, much larger than what was presented. When greywater recycling in multi-family dwelling units and commercial buildings such as hotels becomes more widespread, a city could feasibly get by on half its present water supply without changing indoor water use. The greatest potential for widespread use at this point appears to be new developments in California. If a major developer were to provide homes with these systems included, it could become a springboard for more research and interest into this area and could promote further awareness. Maintenance could be consolidated for this scale. A local possibility for an innovative experiment would be the 15,000 home development planned for a 3,000 acre site in nearby Dougherty Valley in Contra Costa County. Any developer proposing to install greywater systems can expect strong opposition from government agencies, since it essentially takes the control of a portion of the water treatment process out of their hands. As the State Water Resources Control Board warns, "effective greywater use necessitates an informed user in close voluntary cooperation with the local agency (Ingham, 29.) Regulation may be inevitable, but it has been shown that responsible homeowners can effectively use the systems without resulting in any of the feared health problems. Encouragement of greywater recycling is one way in which Santa Clara County water agencies can help the public help them toward their common goal of protecting and conserving our most valuable natural resource.

APPENDIX I. REFERENCES

Arthur D. Little Inc. *Sewerage for Urban Growth, South Santa Clara County*. 1964.

Association of Bay Area Governments. *Projections 96*. 1996.

Association of Bay Area Governments. *San Francisco Bay Area Environmental Management Plan*. Technical Memorandum #27, 1978.

Bilson, S. Correspondence and Personal and Telephone Interviews.

Ball, A. Correspondence and Telephone Interviews.

Bechtel Incorporated. *Financial Plans and Revenue Programs for Water Pollution Control Facilities in South San Francisco Bay*. South Bay Dischargers Authority, 1974.

Brown and Caldwell. *Design and Implementation of Wastewater Reduction Program*. San Jose/Santa Clara Water Pollution Control Plant. 1983.

Brown and Caldwell. *Wastewater Reduction Study*. San Jose/Santa Clara Water Pollution Control Plant. 1982.

California Department of Health Services. *A Homeowner's Guide to Safe Use of Gray Water During a Drought*. 1991.

California Regional Water Quality Control Board. *Reissuing Waste Discharge Requirements for San Jose/Santa Clara Water Pollution Control Plant.*

Christensen, B. *Sustainable Building Sourcebook*. Homepage at www/greenbuilder.com/sourcebook/greywater.html.

City of Los Angeles. Office of Water Reclamation. *Greywater Pilot Project Final Report*. November, 1992.

Cornell Center for the Environment. Arroyo Homepage.

County of Santa Clara. Strategic Vision Steering Committee. *Alternative Futures*. 1990.

David Keith Todd Engineers. *Evaluation of Groundwater Resources in Santa Clara County*. 1987.

Department of Water Resources, Office of Water Conservation. *Graywater Guide; Using Graywater in your Home Landscape*. Sacramento, 1994.

Department of Water Resources, State of California. *California Water Plan Update*. Vol. 1. Bulletin 160-93. Sacramento, 1994.

Farallones Institute. *Grey Water Use in the Home Garden*. Berkeley, 1978.

Freifelder, R. *Stretching the Drops: Making a Little Water go a Long Way*. Home Energy. July/August 1988. p.20.

Fryer, J. Correspondence and Telephone Interview.

Hirano, W. M. and Young, R. H. F. *Greywater Reuse*. Water Resources Research Center. Political Memorandum Report #73. 1983.

Ingham, A. T. *Residential Greywater Management in California*. State Water Resources Control Board. Sacramento, 1980.

Johnson, M. *Water Resources in Santa Clara County*. Santa Clara Valley Water Conservation District. Santa Clara, 1973.

Kasselberg, S. Telephone Interview.

Kizer, K. W. *A Homeowner's Guide to Safe Use of Gray Water During a Drought*. State of California, 1991.

Kull, K. M. *Graywater: A Water Conservation Strategy; An Overview and Feasibility Study for East Bay Municipal Utility District*. University of California at Berkeley, 1994.

Kourik, R. *Gray Water Use in the Landscape*. Metamorphic Press, Santa Rosa 1988.

Koyasako, J. S. *Effects of Water Conservation-Induced Waste Water Flow Reduction*. California Department of Water Resources. Sacramento, 1980.

Linsley, R. K. et al. *Water Resources Engineering*. McGraw-Hill. New York, 1992.

Ludwig, A. *Create an Oasis with Greywater*. PIP, Santa Barbara, 1994.

Marin Municipal Water District. *Proposal for Selecting Graywater Sites*. October 1995.

Parada, C. E-mail correspondence.

Rosenblum, E. E-mail correspondence.

Santa Clara County Planning Office. *Santa Clara County General Plan: Charting a Course for Santa Clara County's Future*. 1995.

Santa Clara Valley Manufacturing Group. *Housing Solutions for Silicon Valley; An Inventory of Vacant Land with Recommendations for Local Governments in Santa Clara County.* 1995.

Santa Clara County Strategic Vision Steering Committee. *Alternative Futures: Trends and Choices*. 1990.

Santa Clara Valley Water District. *1993-94 Annual Report.* 1995.

Sciutto, J. E. and Zamost, B. *Implement a Water-Efficient Landscape Rebate Program.* Building Sustainable Communities Report No. 1185. 1994.

Shiekh, Bahman. Correspondence and Telephone Interview.

Smith, G. E. *Economics of Water Collection and Waste Recycling*. University of Cambridge Technical Research Division. Working Paper 6. 1973.

South Bay Water Recycling. *Freshwater Diversion Alternatives*. December, 1995.

Sun, G. S. *Water Quality of Gray Water for Reuse*. Thesis. University of Arizona. 1986.

United States Census Bureau. *1990 Census of Population and Housing*. Summary Tape File 1A.

United States Bureau of Reclamation. *Draft Environmental Impact Statement for the South Bay Water Recycling Program.* 1995.

United States Bureau of Reclamation. *Central California Regional Water Recycling Project.* 1995.

WateReuse Association of California. *Future Water Recycling Potential.* 1993.

Water Education Foundation. *Western Water*. January/February, 1995.

Winneberger, J. H. T. *Manual of Grey Water Treatment Practice*. Ann Arbor Science, Ann Arbor. 1974.

Wilson, Everett. Environmental Technician, Santa Clara Valley Water District.

APPENDIX II. SUPPORTING TABLES AND FIGURES

Table A.1: Limits of Study Area.

Communities in Santa Clara County:

Campbell
Cupertino
Gilroy
Los Altos
Los Altos Hills
Los Gatos
Milpitas
Monte Sereno
Morgan Hill
Mountain View
Palo Alto
San Jose
Santa Clara
Saratoga
Sunnyvale

Bold = Serviced by SJ/SC treatment plant.

Figure A-1: Maps of area

(Map from Bechtel 3-3)
(Map from SCVWD, 18)

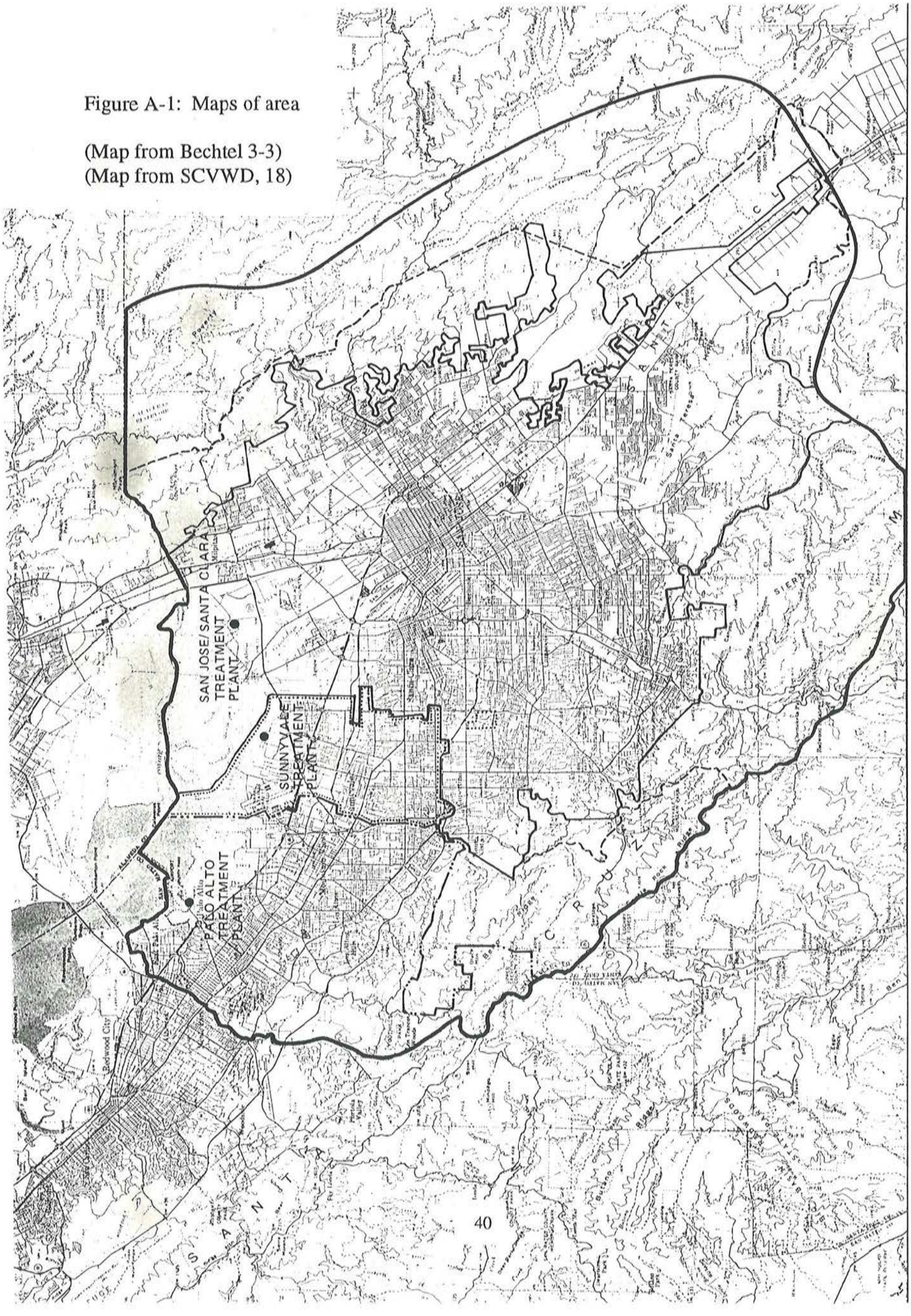


Table A.2: Water Purveyors and Sources of Supply in Santa Clara Valley.

Water Supplier	*Source of Supply*
City of Palo Alto	Hetch-Hetchy
City of Mountain View	Hetch Hetchy, Groundwater
City of Sunnyvale	Groundwater, South Bay Aqueduct, Hetch-Hetchy
Purissima Hills Water District	Hetch-Hetchy
California Water Service Company	Groundwater, South Bay Aqueduct, Hetch-Hetchy
City of Cupertino	South Bay Aqueduct, Groundwater
City of Santa Clara	Groundwater, South Bay Aqueduct, Hetch-Hetchy
City of San Jose	Hetch-Hetchy, Groundwater
City of Milpitas	Hetch-Hetchy
San Jose Water Company	Groundwater, South Bay Aqueduct, SJWC trtmnt. plant
Great Oaks Water Company	Groundwater
City of Morgan Hill	Groundwater
West San Martin Water Works	Groundwater
City of Gilroy	Groundwater
Santa Clara Valley Water District	Groundwater, South Bay Aqueduct

Source: Santa Clara Valley Water District, 1984.

Figure A-2: Map of Water Supplier Jurisdictions.

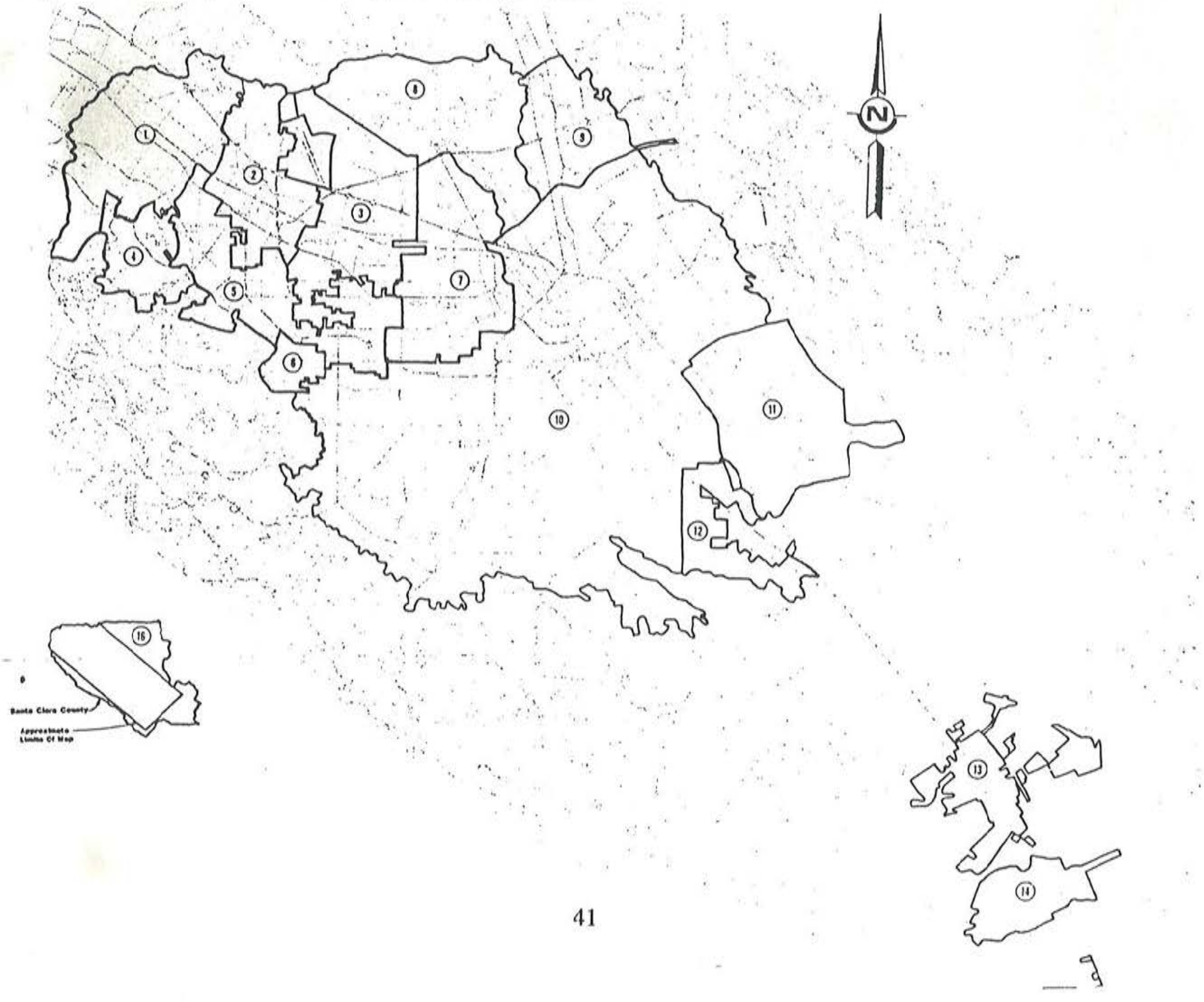


Figure A.3: Annual Savings from Greywater Systems.
(Source: L.A. Pilot Study.)

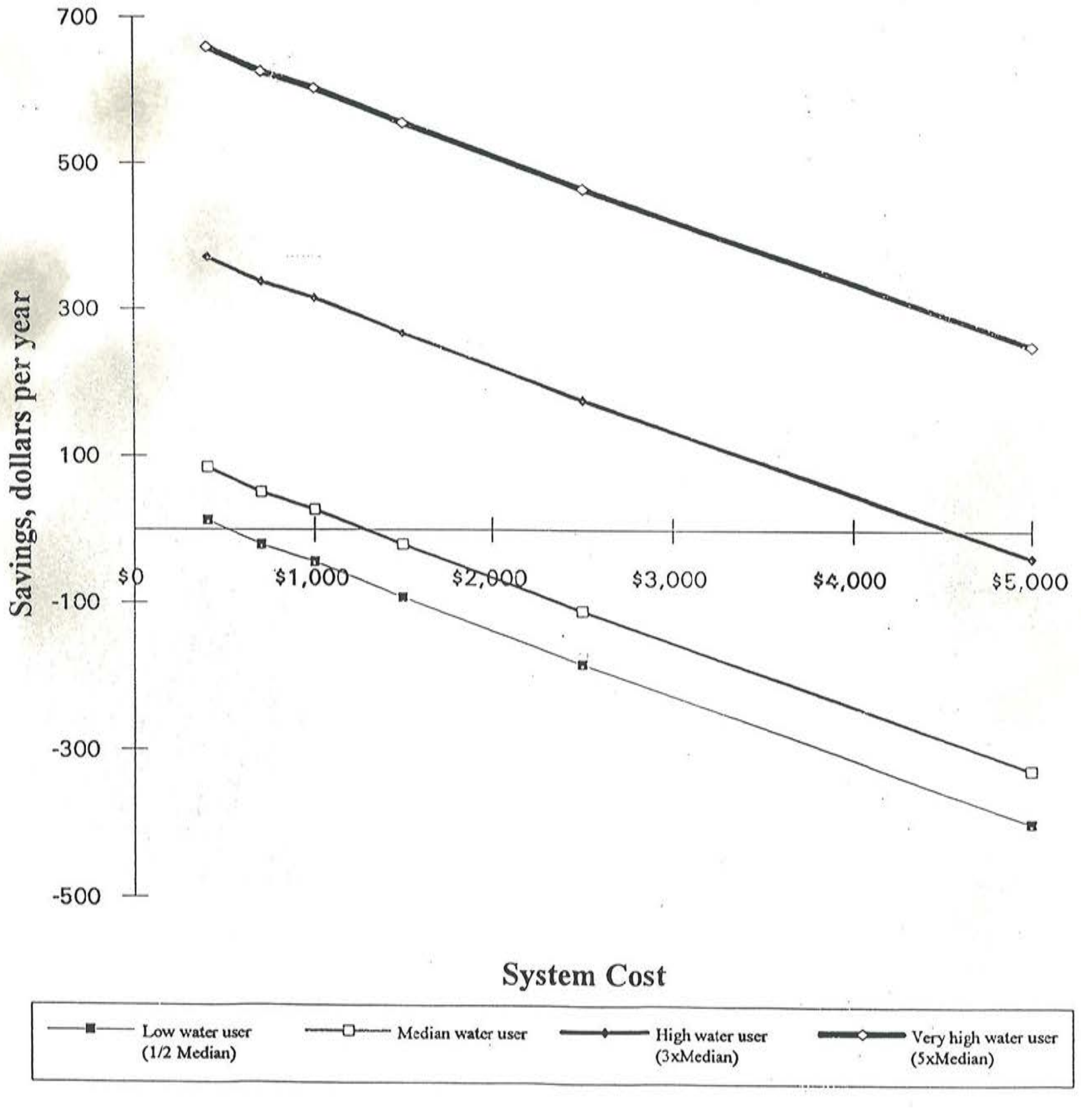
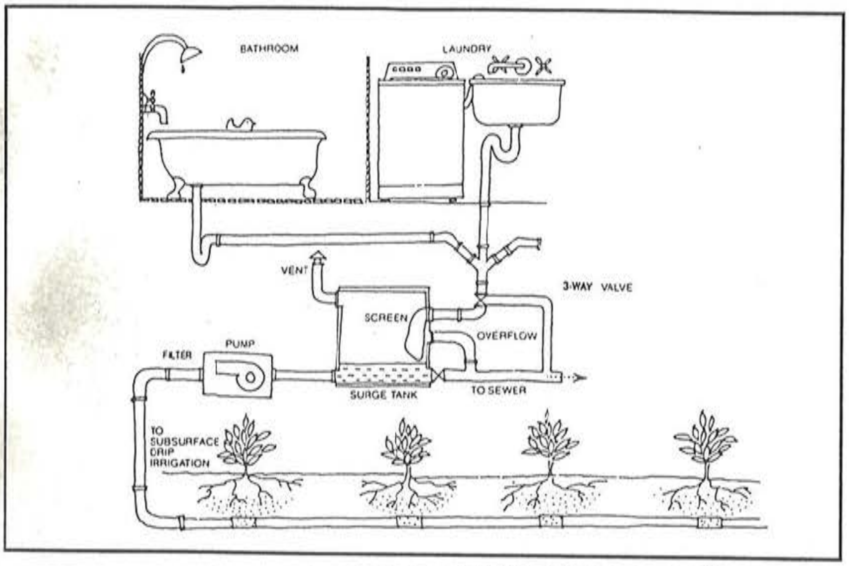


Figure A.4: Diagram of a Typical Greywater Recycling System.

(Winneberger "Treatment Practices" 40)
(Ludwig 17, Graywater Guide 13)



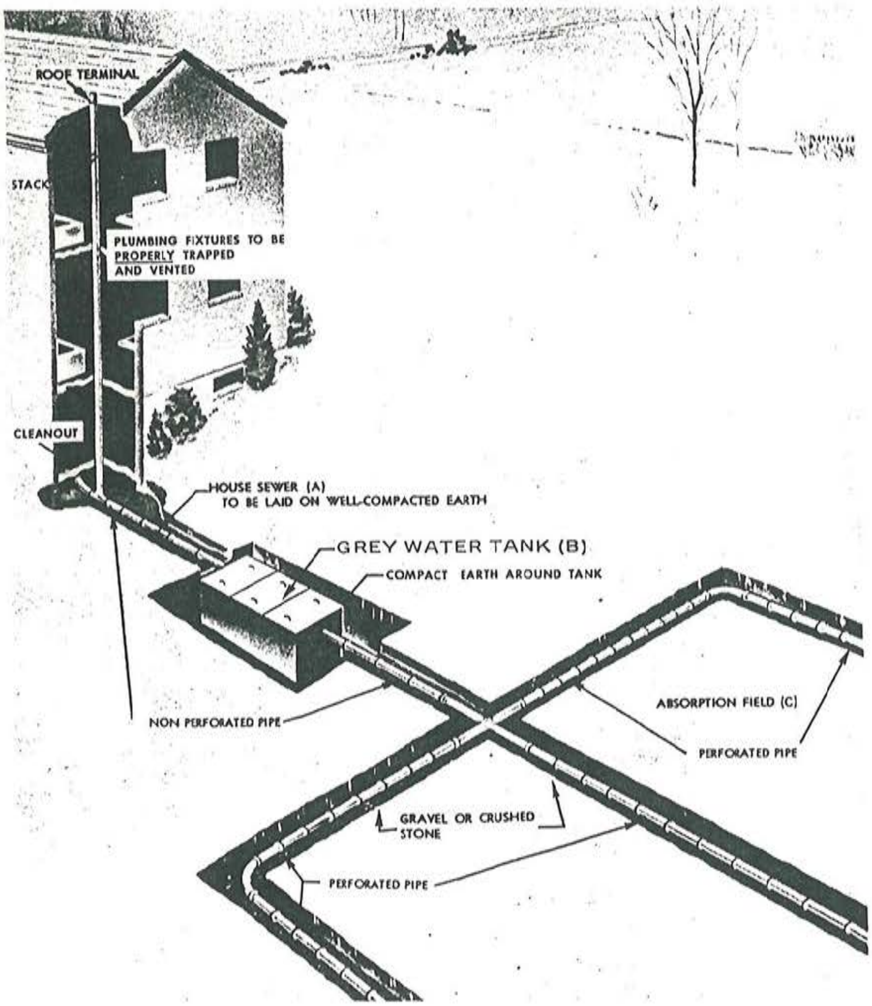


Table A.3: City of San Jose Sewer Fees (1995-96).

SAN JOSE
CAPITAL OF SILICON VALLEY

SEWER FEES
(Effective July 1, 1995 - June 30, 1996)

Department of Public Works, Development Services
801 N. First Street, Room 308 , San Jose, CA 95110
(408) 277-5161 FAX (408) 277-3879

Storm Fees

Residential - Single Family & Duplex	Less than 9,680 S.F. Greater than 9,680 S.F.	$270 per lot $1,215 per acre
Residential - Multi-Family	Less than 9,720 S.F. Greater than 9,720 S.F.	$405 per lot $1,815 per acre
Non-Residential	Less than 9,720 S.F. Greater than 9,720 S.F.	$405 per lot $1,815 per acre upto 10 acres $1,8150 + $865 per acre over 10 acres
Schools		$900 per acre or $205 per lot whichever is greater

Sanitary Fees

Residential - Single Family & Duplex	Less than 9,780 S.F. Greater than 9,780 S.F.	$447 per lot $1,991 per acre
Residential - Multi-Family	Less than 9,780 S.F. Greater than 9,780 S.F.	$447 per lot + $194 for each living unit over 2 units per lot $1,991 per acre + $194 for each living unit over 7 units per acre
Non-Residential	Less than 9,780 S.F. Greater than 9,780 S.F.	$447 per lot + $194 for each "living unit equivalent*" over 2 units per lot $1,991 per acre + $194 for each "living unit equivalent" over 7 units per acre for the first 10 acres. Plus $861 per acre above 10 acres
Schools		$1,475 per acre or $333 per lot, whichever is greater
Sanitary Sewer Connection in excess of 25,000 gallons per day (peak flow)		Consult Staff for fee calculation

*Note: Each living unit is equivalent to 240 gallons per day

Sewage Treatment Plant Connection Fees

Residential	
Single Family Dwelling	$780 per unit
Multiple Family Dwelling	$438 per unit
Mobile Home	$438 per unit
Non-Residential	Computation of this fee requires specific calculations by staff. This fee may vary greatly depending upon the amount of sewage generated by the proposed land use.

Table A.4: Water Rates in Santa Clara County (1995).

SAN JOSE MUNICIPAL WATER SYSTEM
SCHEDULE OF RATES AND MONTHLY CHARGES FOR WATER SERVICE
Resolution No. 65466
Effective January 1, 1995

Monthly Quantity Charges for Single Family Dwellings ($ per HCF)

TIER	ZONE 1 E	ZONE 2 F	EVERGREEN ZONES 3, 4 G	EVERGREEN ZONES 5, 6 I	EDENVALE C	COYOTE K	ALVISO A	NSJ N
0-7 HCF	$1.13	$1.21	$1.28	$1.36	$1.13	$1.13	$1.13	$1.13
8-14 HCF	$1.35	$1.43	$1.50	$1.58	$1.35	$1.35	$1.35	$1.35
15-21 HCF	$1.55	$1.63	$1.70	$1.78	$1.55	$1.55	$1.55	$1.55
>21	$1.75	$1.83	$1.90	$1.98	$1.75	$1.75	$1.75	$1.75

Monthly Quantity Charges for Multi Family Dwellings ($ per HCF)

TIER	ZONE 1 E	ZONE 2 F	EVERGREEN ZONES 3, 4 G	EVERGREEN ZONES 5, 6 I	EDENVALE C	COYOTE K	ALVISO A	NSJ N
0-7 HCF x (# of units)	$1.13	$1.21	$1.28	$1.36	$1.13	$1.13	$1.13	$1.13
>7-14 HCF x (# of units)	$1.35	$1.43	$1.50	$1.58	$1.35	$1.35	$1.35	$1.35
>14-21 HCF x (# of units)	$1.55	$1.63	$1.70	$1.78	$1.55	$1.55	$1.55	$1.55
>21 HCF x (#of units)	$1.75	$1.83	$1.90	$1.98	$1.75	$1.75	$1.75	$1.75

Monthly Quantity Charges for Non-Residential ($ per HCF)

TIER	ZONE 1 E	ZONE 2 F	EVERGREEN ZONES 3, 4 G	EVERGREEN ZONES 5, 6 I	EDENVALE C	COYOTE K	ALVISO A	NSJ N
All HCF	$1.35	$1.43	$1.50	$1.58	$1.35	$1.35	$1.35	$1.35

Figure A-5: Effects of water conservation on treatment plant operating costs.

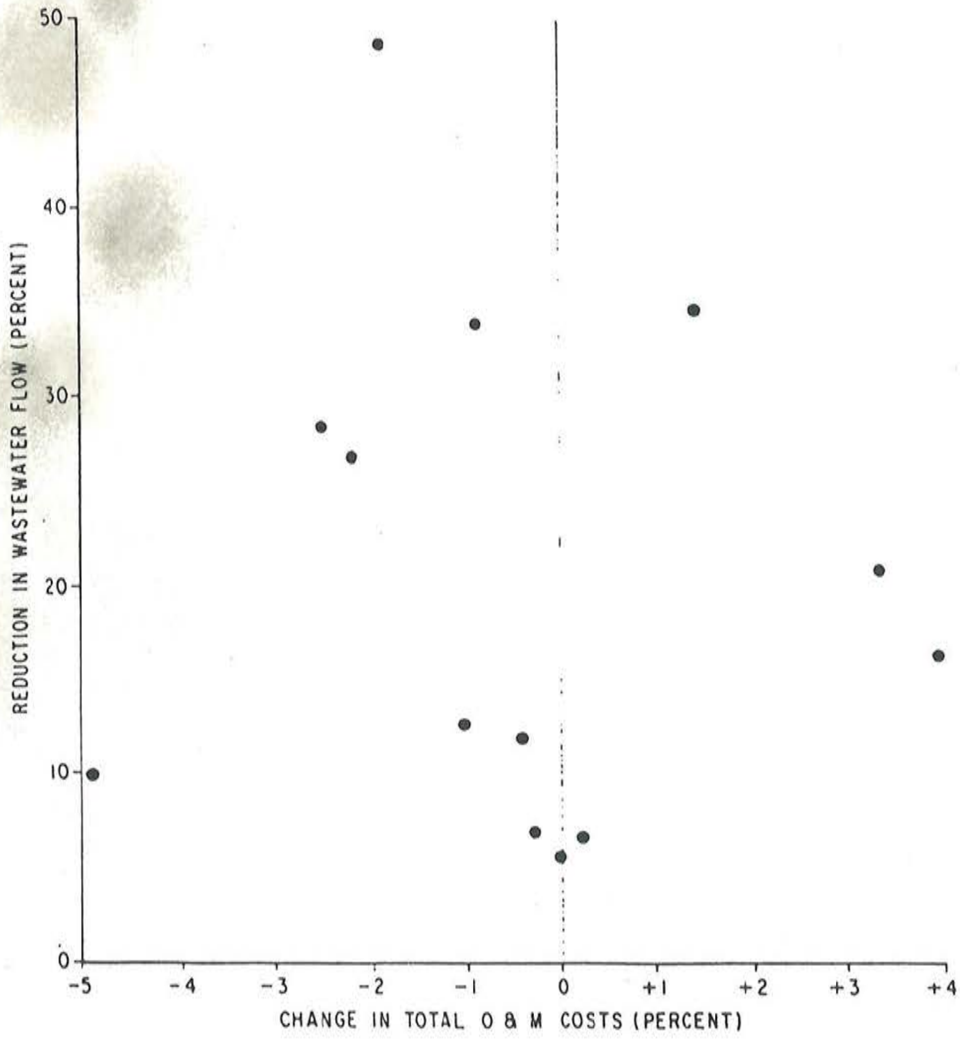


Figure A-6: Calculations for homeowner savings without rate increases or landscaping.

Present value of costs: **$1,000**

Present value of benefits:

Using the formula: $\left(\frac{P}{A}\right)_n^i = \frac{(1+i)^n - 1}{i(1+i)^n}$, the following values are obtained:

(P/A, 3%, 20) = 14.88

P = A * (P/A)

(maint. costs subtracted) P = 67 * 15 = $997

Rate increase benefits: $\left(\frac{P}{G}\right)_n^i = \frac{(1+i)^n - 1}{i^2(1+i)^n} - \frac{n}{i(1+i)^n}$

(P/G, 3%, 20) = 126.8

P = G * (P/G)

P = 5.85 * 127= $742

Total benefits: $997 + $742 = **$1739**

n = 20 yrs, i = 3%, G = $5.85/yr

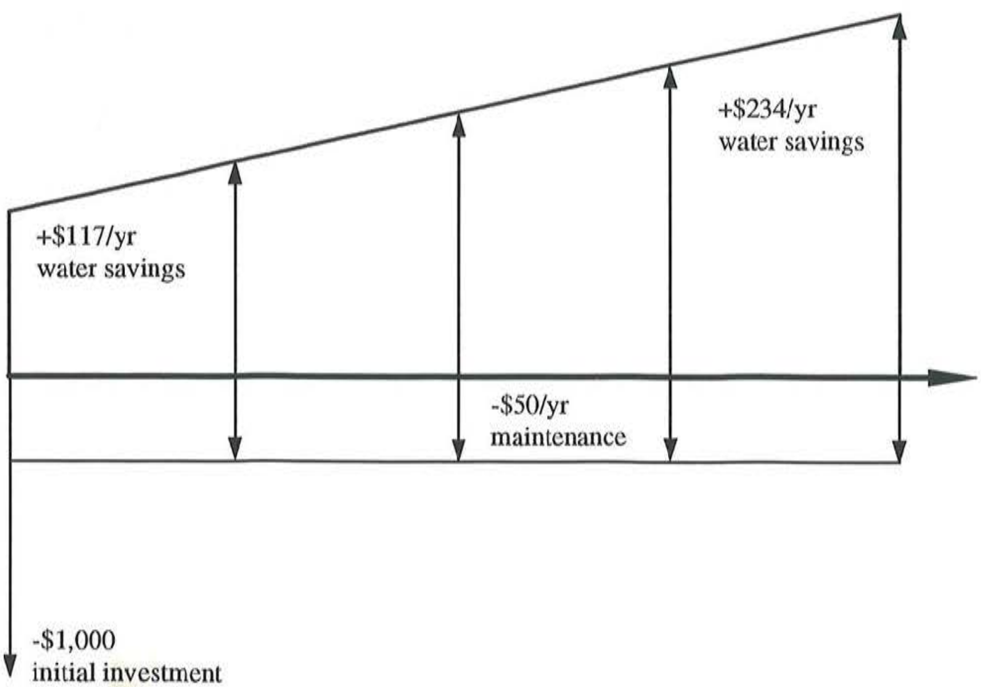


Figure A.7: Vacant Residential Land in Santa Clara County.

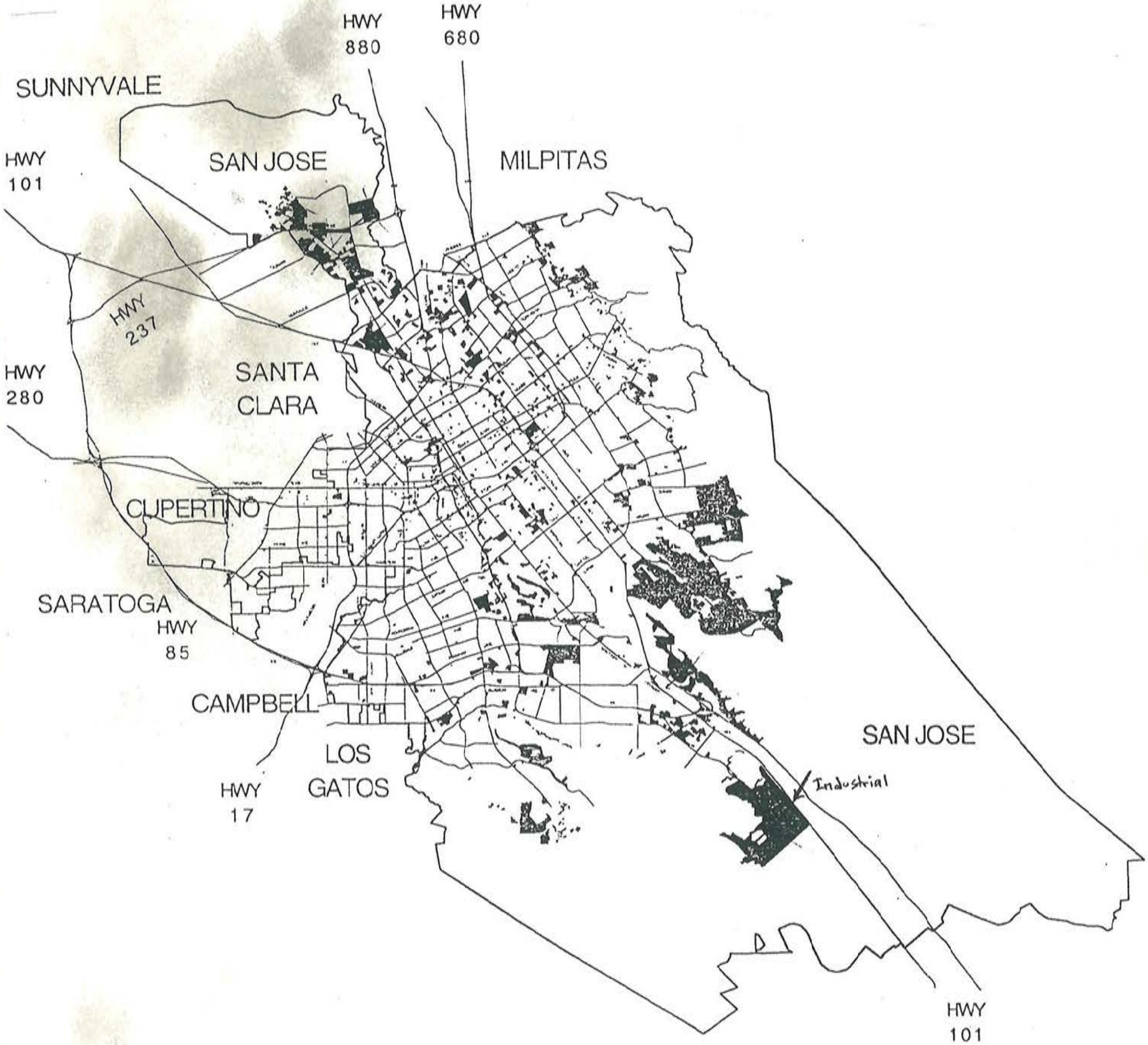


Figure A-8: Areas of Highest Potential Growth in San Jose.

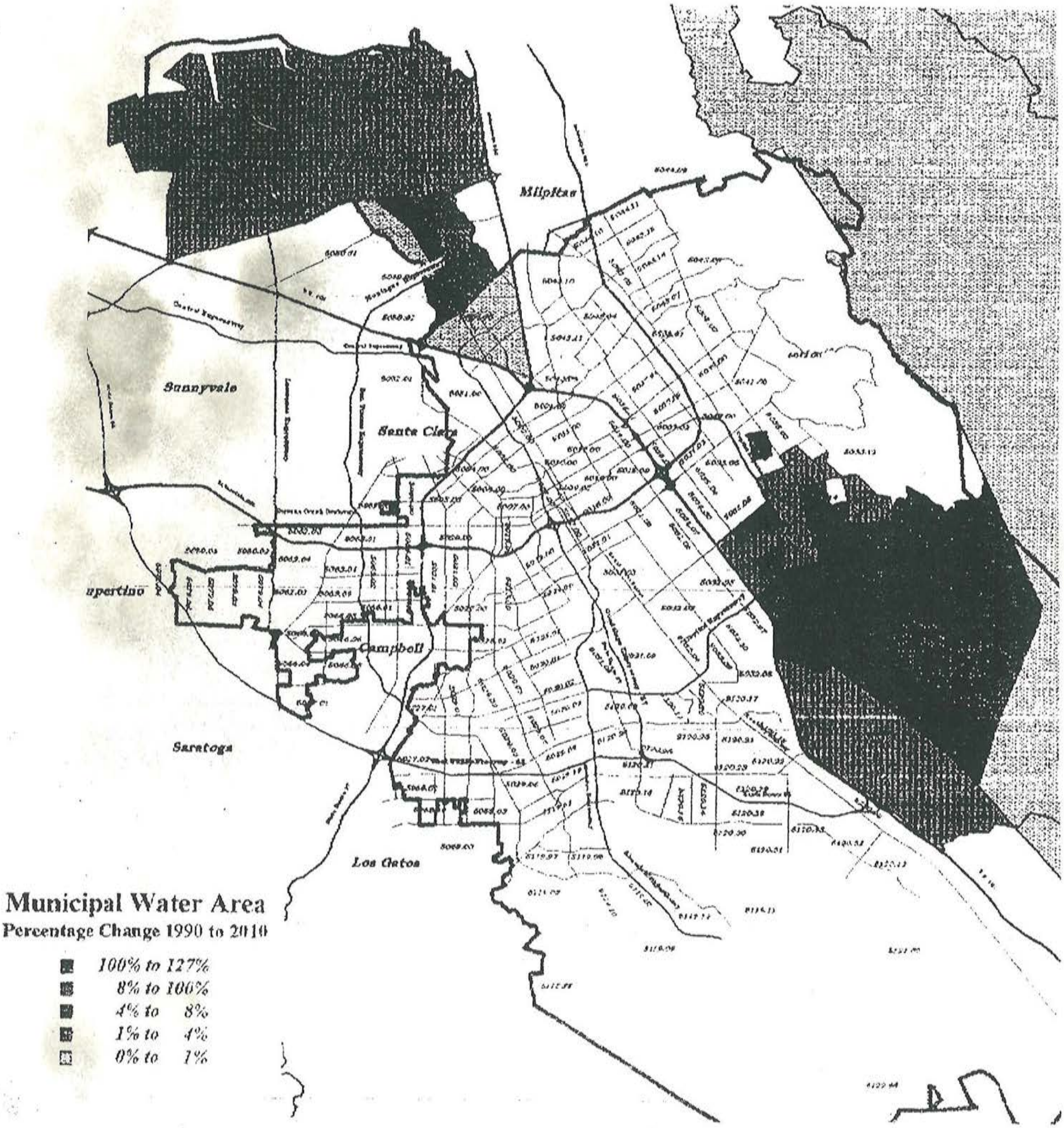


Figure A.9: Groundwater Protection Zones in Santa Clara County.

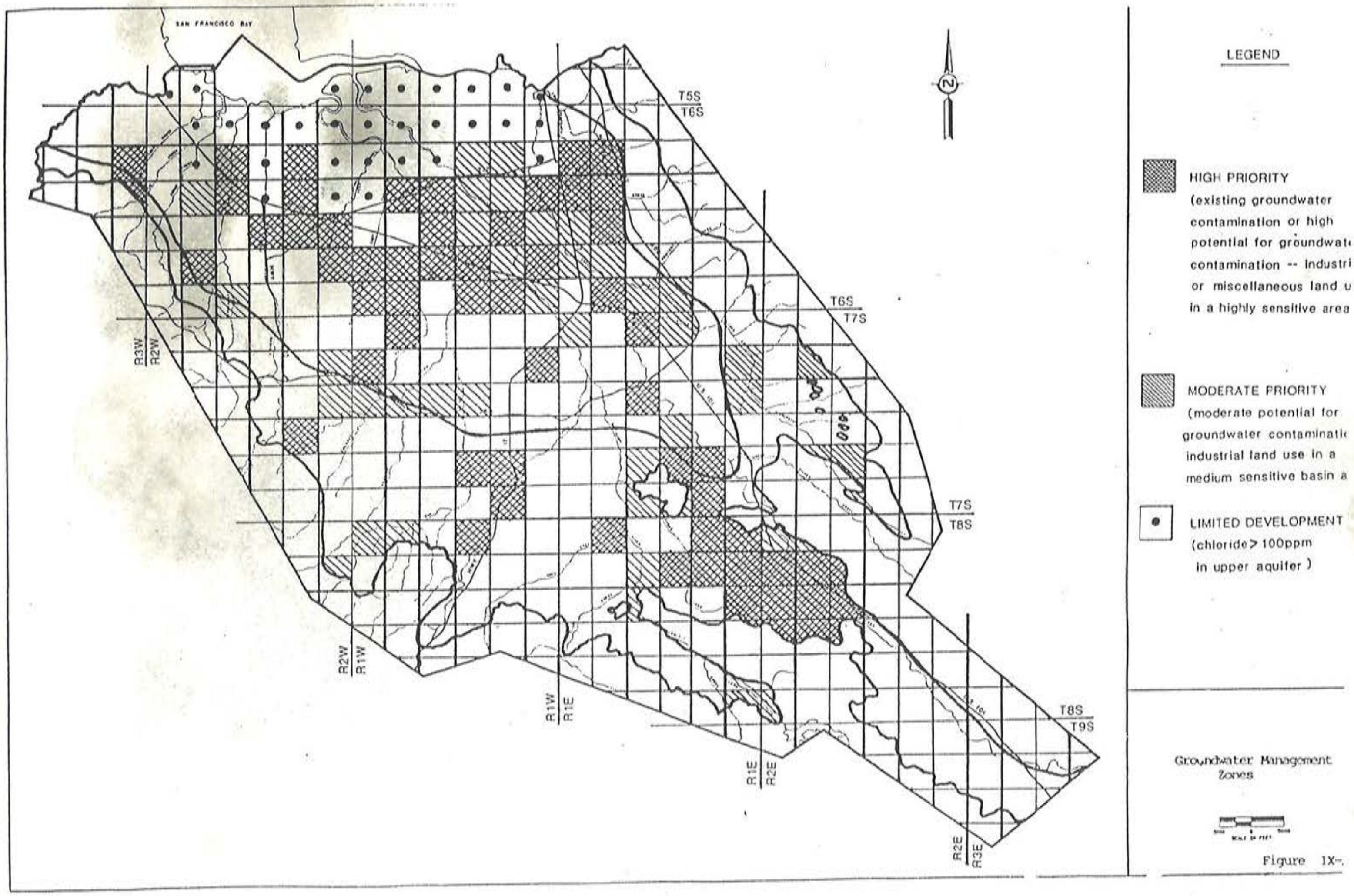


Table A-5: Formula for Calculating Irrigation Potential.

(Source DWR Graywater Guide, 4)

Use this formula to estimate the square footage of the landscape to be irrigated:

$$LA = \frac{GW}{ET \times PF \times 0.62}$$

where:

LA = landscaped area (square feet)

GW = estimated graywater produced (gallons per week)

ET = evapotranspiration* (inches per week)

PF = plant factor

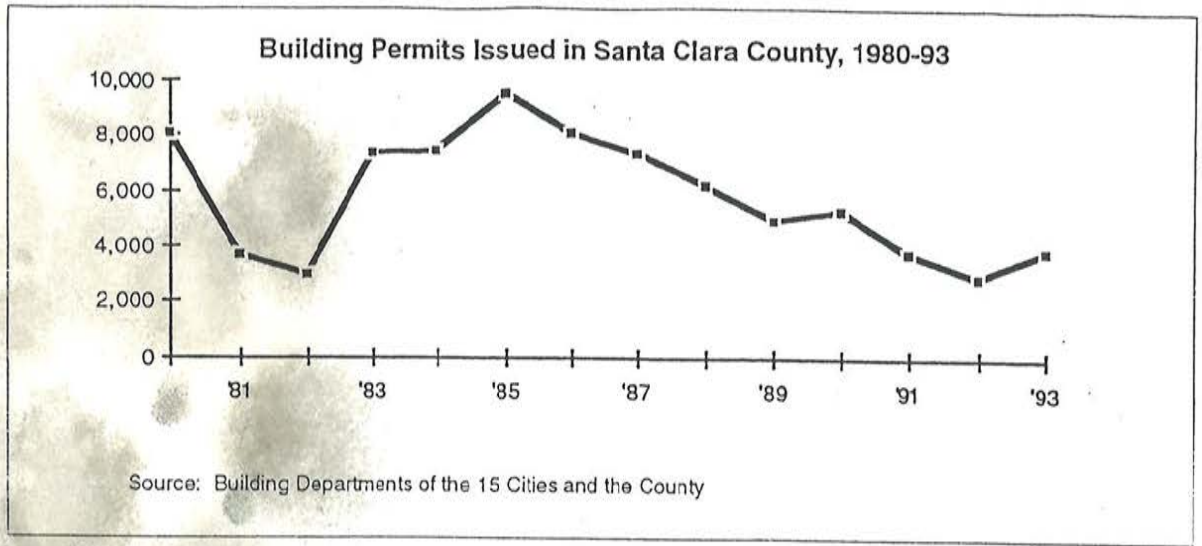
0.62 = conversion factor (from inches of ET to gallons per week)

*Evapotranspiration is the amount of water lost through evaporation (E) from the soil and transpiration (T) from the plant. (This formula does not account for irrigation efficiency. If your irrigation system does not distribute water evenly, extra water will need to be applied.)

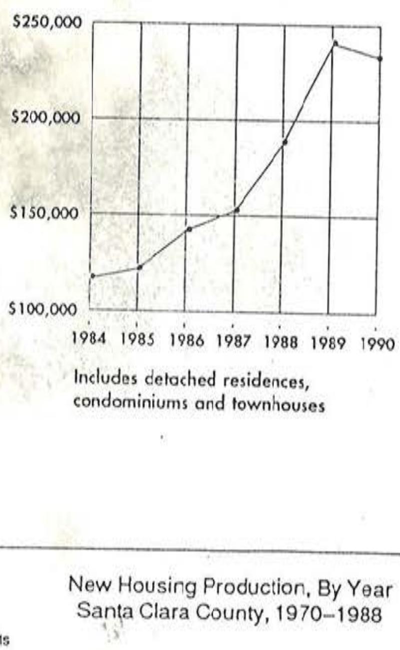
Climate	Relative Water Need of Plant (Plant Factor)	Gallons Per Week 200 SQ FT CANOPY	100 SQ FT CANOPY	50 SQ FT CANOPY
Coastal	low water using (0.3)	38	19	10
(ET=1in/wk)	medium water using (0.5)	62	31	16
	high water using (0.8)	100	50	25
Inland	low water using (0.3)	76	38	19
(ET=2in/wk)	medium water using (0.5)	124	62	31
	high water using (0.8)	200	100	50
Desert	low water using (0.3)	114	57	28
(ET=3in/wk)	medium water using (0.5)	186	93	47
	high water using (0.8)	300	150	75

[The gallons per week calculation for this chart was determined with the following formula: Gallons per week = ET x plant factor x area x .62 (conversion factor.)(This formula does not account for irrigation efficiency. If your irrigation system does not distribute water evenly, extra water will need to be applied.)]

Figures A-10-20: Supplemental Figures.



Santa Clara County Median Home Prices (priced in June)



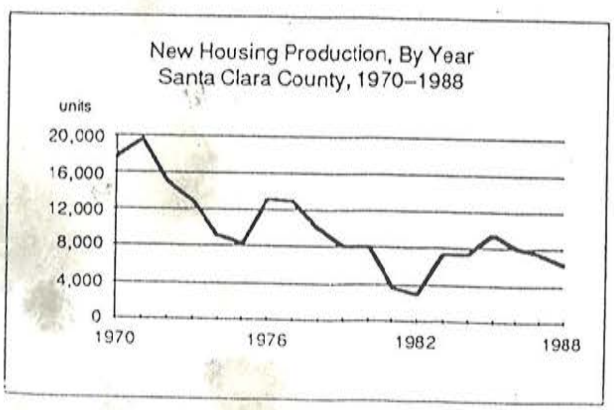
Includes detached residences, condominiums and townhouses

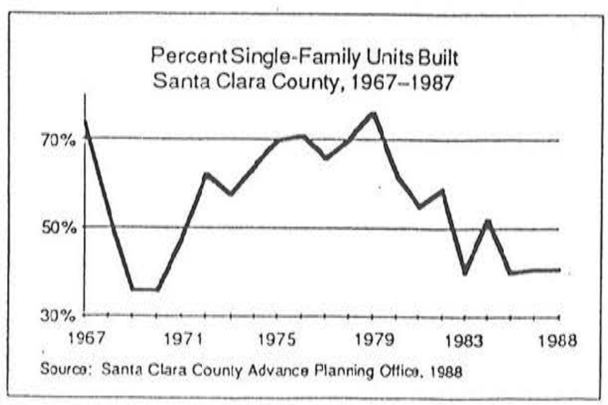
The actual countywide housing production for 1990 through 1994 is as follows:

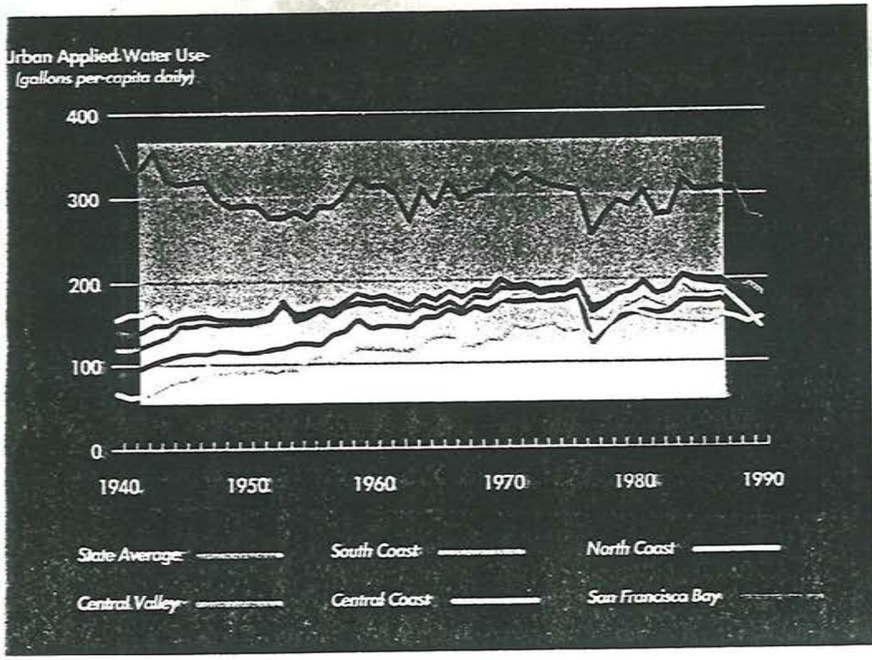
YEAR	UNITS BUILT
1990	5,321
1991	3,765
1992	2,836
1993	3,439
1994	3,954

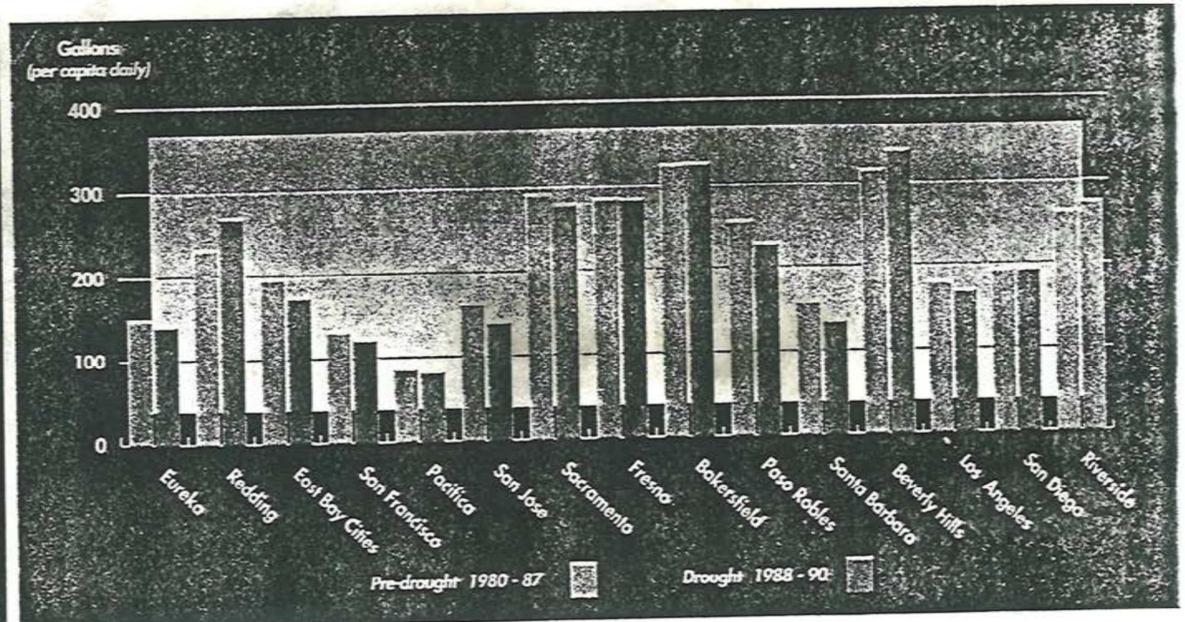
1990-1994 Production Total 19,315 units

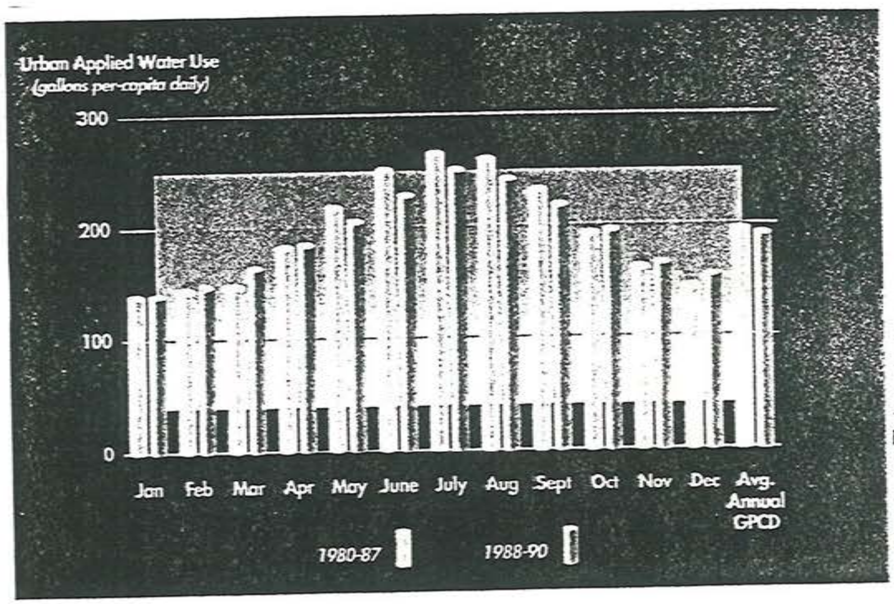
1990-1994 Housing Production Shortfall 10,685 units







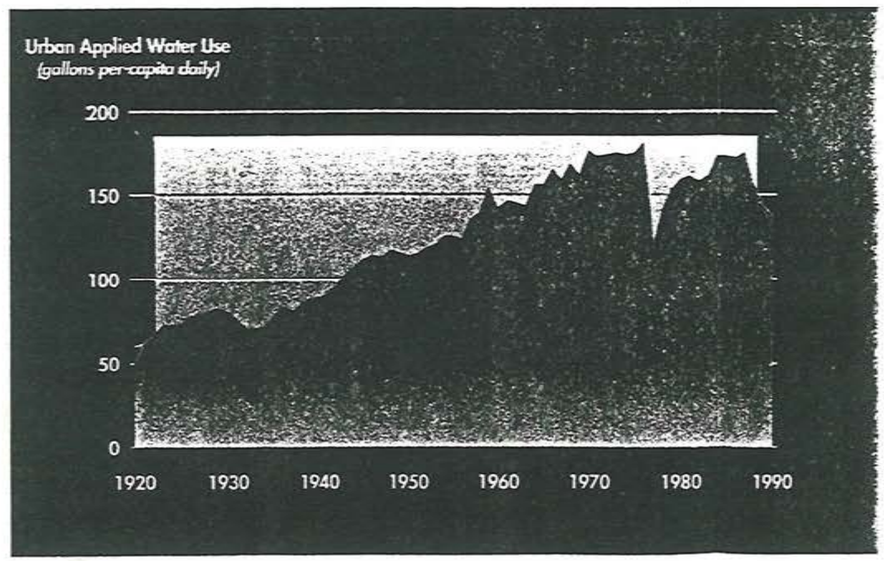


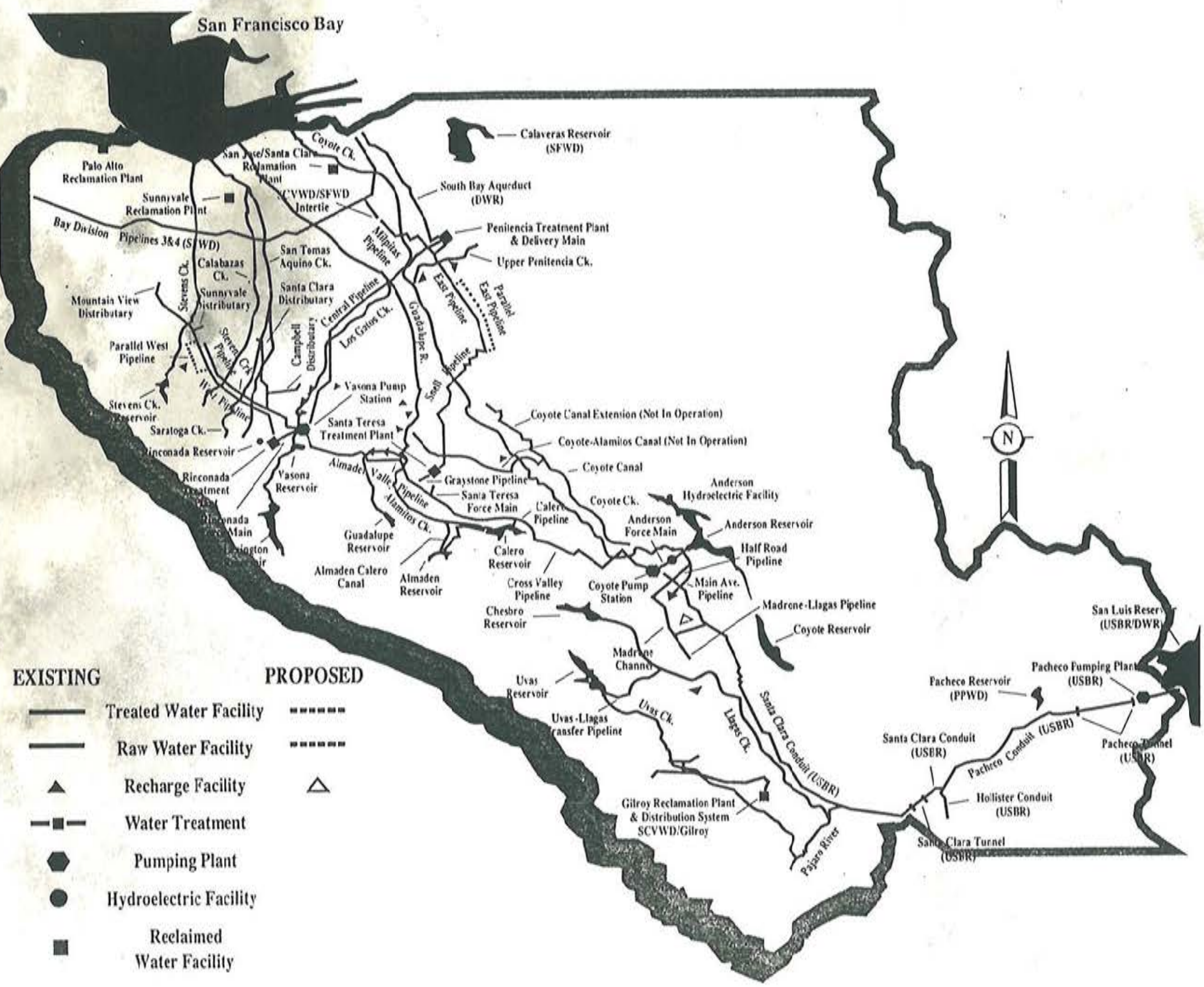


Urban Per Capita Water Use San Francisco Bay Area 1920–1990

Average Monthly Urban Per Capita Water Use Statewide

Does not include self-supplied water.




San Francisco Bay
Calaveras Reservoir (SFWD)
Palo Alto Reclamation Plant
Sunnyvale Reclamation Plant
South Bay Aqueduct (DWR)
Penitencia Treatment Plant & Delivery Main
Upper Penitencia Ck.
Bay Division Pipelines 3&4 (SFWD)
San Tomas Aquino Ck.
Calabazas Ck.
Santa Clara Distributary
Mountain View Distributary
Sunnyvale Distributary
Stevens Ck.
Parallel West Pipeline
Central Pipeline
Los Gatos Ck.
Guadalupe R.
Milpitas Pipeline
East Pipeline
Parallel East Pipeline
Snell Pipeline
Coyote Ck.
Campbell Distributary
Vasona Pump Station
Santa Teresa Treatment Plant
Saratoga Ck.
Vasona Reservoir
Coyote Canal Extension (Not In Operation)
Coyote-Alamitos Canal (Not In Operation)
Coyote Canal
Graystone Pipeline
Santa Teresa Force Main
Almaden Valley Pipeline
Alamitos Ck.
Guadalupe Reservoir
Almaden Calero Canal
Almaden Reservoir
Calero Reservoir
Calero Pipeline
Cross Valley Pipeline
Chesbro Reservoir
Coyote Pump Station
Anderson Hydroelectric Facility
Anderson Force Main
Anderson Reservoir
Half Road Pipeline
Main Ave. Pipeline
Madrone-Llagas Pipeline
Coyote Reservoir
Uvas Reservoir
Uvas Ck.
Llagas Ck.
Santa Clara Conduit (USBR)
Gilroy Reclamation Plant & Distribution System SCVWD/Gilroy
Pajaro River
Santa Clara Conduit (USBR)
Pacheco Conduit (USBR)
Hollister Conduit (USBR)
Pacheco Reservoir (PPWD)
Pacheco Pumping Plant (USBR)
N
EXISTING
PROPOSED
Treated Water Facility
Raw Water Facility
Recharge Facility
Water Treatment
Pumping Plant
Hydroelectric Facility
Reclaimed Water Facility

Tables A-6-7: Supplemental Tables.

Table 1
Economic and Demographic Assumptions Underlying Projections 96

	1990 - 1995	1995 - 2000	2000 - 2015
National Assumptions			
Annual Compound Growth Rate of Real GDP	2.50%	2.80%	3.00%
Commercial Interest Rate	5.90%	6.90%	5.50%
Regional Economic Assumptions			
Annual Compound Real Growth Rate in All Gross Exports	2.90%	4.00%	4.60%
Annual Compound Real Growth Rate in High Tech and Information Technology Gross Exports[a]	9.00%	8.00%	7.10%
Mortgage Interest Rate	8.50%	7.90%	7.00%
Annual Compound Energy Cost Increases in Current $	3.50%	4.50%	5.00%
Annual Compound Increase in Output per Worker (in real terms) over All Industries	2.20%	2.10%	1.90%
Annual Compound Increase in Output per Worker (in real terms) in Electronics[b]	8.30%	7.60%	6.00%
Annual Compound Growth in Personal Consumption Expenditures (PCE) (in real terms)	1.40%	2.60%	2.10%
Annual Compound Real Growth in Capital Spending	2.90%	3.20%	3.30%
Annual Compound Growth in Gross Regional Product (GRP)	1.60%	3.50%	3.00%
Regional Demographic Assumptions			
Annual Compound Growth Rate in Labor Force Participation	0.07%	1.80%	0.90%
Percent Change in Regional Household Size	3.80%	1.48%	-2.91%
Period Fertility Rate (births per female, ages 15–44)	2.06	2.05	2.00
Net Annual Regional Migration	39,900	41,500	17,000

[a] computers, electronics, instruments, fraction of business services, communications equipment, software, R & D

[b] computers, communications equipment and instruments (SIC 357, 366, 367, 369, 38)

Demographic Change in Santa Clara County
Top Subregional Study Areas: 2005 - 2015

POPULATION	2005-2015 CHANGE	HOUSEHOLDS	2005-2015 CHANGE	EMPLOYED RESIDENTS	2005-2015 CHANGE	JOBS	2005-2015 CHANGE
San Jose	47,500	San Jose	21,550	San Jose	30,600	San Jose	37,790
Gilroy	14,700	Gilroy	4,780	Gilroy	7,800	Santa Clara	10,820
Morgan Hill	9,100	Santa Clara	4,620	Santa Clara	7,400	Sunnyvale	9,220
Santa Clara	9,000	Sunnyvale	4,080	Sunnyvale	5,900	Gilroy	7,620
Sunnyvale	7,400	Morgan Hill	3,290	Morgan Hill	4,900	Mountain View	7,100
Palo Alto	1,700	Mountain View	1,520	Mountain View	1,800	Morgan Hill	6,850
Cupertino	500	Palo Alto	970	Milpitas	1,000	Milpitas	5,960
Remainder	500	Campbell	480	Palo Alto	1,000	Cupertino	3,670
Campbell	300	Milpitas	460	Campbell	700	Palo Alto	2,140
Milpitas	300	Cupertino	390	Cupertino	700	Los Gatos	1,500
Saratoga	-200	Remainder	280	Remainder	500	Campbell	1,210
Los Altos Hills	100	Los Gatos	210	Saratoga	400	Saratoga	640
Los Gatos	-100	Saratoga	170	Los Altos	200	Remainder	110
Monte Sereno	-100	Los Altos	80	Los Gatos	-100	Los Altos Hills	80
Mountain View	-100	Los Altos Hills	80	Los Altos Hills	0	Los Altos	70
Los Altos	0	Monte Sereno	20	Monte Sereno	0	Monte Sereno	50

POPULATION	2005-2015 PERCENTAGE CHANGE	HOUSEHOLDS	2005-2015 PERCENTAGE CHANGE	EMPLOYED RESIDENTS	2005-2015 PERCENTAGE CHANGE	JOBS	2005-2015 PERCENTAGE CHANGE
Gilroy	29 %	Gilroy	31 %	Gilroy	31 %	Morgan Hill	46 %
Morgan Hill	22 %	Morgan Hill	25 %	Morgan Hill	23 %	Gilroy	32 %
Santa Clara	8 %	Santa Clara	11 %	Santa Clara	12 %	Milpitas	13 %
Sunnyvale	5 %	Sunnyvale	7 %	Sunnyvale	7 %	Mountain View	11 %
San Jose	5 %	San Jose	7 %	San Jose	6 %	San Jose	10 %
Remainder	3 %	Remainder	5 %	Remainder	5 %	Saratoga	10 %
Monte Sereno	-3 %	Mountain View	5 %	Mountain View	4 %	Santa Clara	10 %
Palo Alto	2 %	Palo Alto	3 %	Milpitas	3 %	Monte Sereno	9 %
Los Altos Hills	1 %	Los Altos Hills	3 %	Campbell	3 %	Cupertino	9 %
Cupertino	1 %	Campbell	3 %	Saratoga	3 %	Los Gatos	8 %
Campbell	1 %	Milpitas	3 %	Palo Alto	2 %	Sunnyvale	8 %
Saratoga	-1 %	Cupertino	2 %	Cupertino	2 %	Campbell	5 %
Milpitas	0 %	Saratoga	2 %	Los Altos	1 %	Remainder	5 %
Los Gatos	0 %	Los Gatos	2 %	Los Gatos	-1 %	Los Altos Hills	3 %
Mountain View	0 %	Monte Sereno	1 %	Los Altos Hills	0 %	Palo Alto	2 %
Los Altos	0 %	Los Altos	1 %	Monte Sereno	0 %	Los Altos	1 %