

# From Watts to Water



***Climate Change Response through  
Saving Water, Saving Energy, and  
Reducing Air Pollution***





## Our Mission

The mission of the District is a healthy, safe, and enhanced quality of living in Santa Clara County through watershed stewardship and comprehensive management of water resources in a practical, cost-effective, and environmentally sensitive manner.

**Santa Clara Valley  
Water District**<sup>SM</sup>



## Santa Clara Valley Water District, Board of Directors

---

**Rosemary Kamei** District 1

**Joe Judge** District 2

**Richard P. Santos** District 3

**Larry Wilson** District 4

**Gregory A. Zlotnick** District 5

**Tony Estremera** At Large

**Sig Sanchez** At Large



**Front row**, seated (from left to right): Sig Sanchez, Rosemary Kamei, Gregory Zlotnick

**Back row**, standing (from left to right): Joe Judge, Tony Estremera, Larry Wilson, Richard Santos

---

### Water Utility Enterprise

#### **Walt Wadlow**

Chief Operating Officer

### Water Supply Management Division

#### **Keith Whitman**

Deputy Operating Officer

#### **Melanie Richardson**

Assistant Operating Officer

#### **Acknowledgements**

##### Water Utility Engineering Unit

**John Brosnan**, Unit Manager

**Amandeep Saini**, Assistant Electrical Engineer II

**Arvind Tailor**, Associate Electrical Engineer

##### Operations, Planning and Analysis Unit

**Jeff Micko**, Unit Manager

##### Imported Water Unit

**Joan Maher**, Unit Manager

**Greg Meamber**, Senior Engineer

**Lynn Hurley**, Senior Project Manager

##### Water Supply Sustainability Planning Unit

**James Crowley**, Unit Manager

### Water Use Efficiency Unit

#### **Report by**

**Jeannine Larabee** Water Conservation Specialist II  
**Hossein Ashktorab, Ph.D.** Unit Manager

#### **Acknowledgements**

**Jerry De La Piedra** Senior Water Conservation Specialist

**Kurt Elvert** Water Conservation Specialist I

**Kevin Galvin** Water Conservation Specialist II

**Rolando Gonzalez** Public Information Representative I

**Pam John** Senior Civil Engineer

**Kelly Jost** Water Conservation Specialist I

**Karen Morvay** Water Conservation Specialist II

**Alice Ringer** Program Administrator

**Robert Siegfried** Assistant Engineer II

**Toni Vye** Senior Office Specialist

**Ray Wong** Associate Engineer (Civil)

**Stanley Zhu** Senior Civil Engineer

#### **Student Interns**

Catherine Cox, Justin Finch, Michael Gonzales, Sven Rosengreen, Elizabeth Sarmiento, & Julianna Wittmann

#### **For more information, please contact**

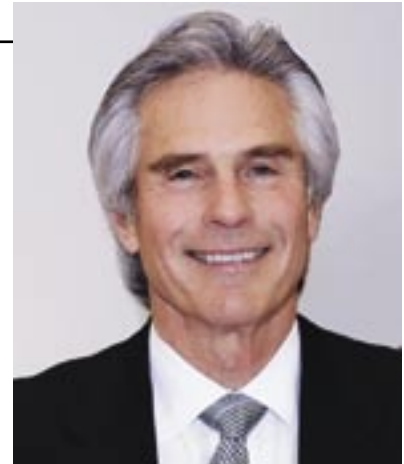
**[waterenergy@valleywater.org](mailto:waterenergy@valleywater.org)**

or 408-265-2607, Ext. 3201

## From the CEO

---

Over the past decade, global warming and climate change have emerged as forefront issues of concern among water agencies. Global climate change is now viewed as one of the most significant long-term threats to water resources management. The predicted effects of climate change will significantly impact water quality and supply as well as the ability to manage flood control issues because greenhouse gases released through fossil fuel combustion are causing global temperatures to rise and altering climate and precipitation patterns. The Santa Clara Valley Water District (District) has identified global climate change as one of its strategic challenges, one which will require new or additional initiatives to address the potential impacts to water resources in Santa Clara County.



The District remains committed to ensuring a reliable water supply through practical and environmentally sensitive management of water resources as well as clean, green business practices. Global climate change and population growth will make it increasingly difficult to meet the growing demand for water while maintaining the health of the watersheds. In addition, the energy required for water supply will further exacerbate the effects of global climate change. In response to the challenges of global climate change, the District is placing increasing emphasis on improving energy efficiency, water use efficiency, and environmental stewardship. Toward this end, the District established programs focused on water use efficiency and has continued its development of innovative water use efficiency programs for reducing the demand on countywide water supplies. The District is also focused on renewable energy sources for its operations, with a hydroelectric generation facility that generates electricity for the electric grid and a recently completed a solar energy project that provides electricity for its headquarters campus.

It has become increasingly clear that the water savings from water use efficiency programs results in significant energy savings and air quality benefits, including reductions of greenhouse gases such as carbon dioxide. The District recently examined the energy savings and reductions in carbon dioxide and other air emissions that occurred as a result of its water use efficiency programs. From FY 92-93 through FY 05-06, the District saved 1.42 billion kWh of energy (worth \$183 million assuming average residential electricity rates) and eliminated 335 million kg of carbon dioxide emissions; the latter is equivalent to removing 72,000 passenger cars from the roads for one year.

In addition to meeting the District's goals for green business practices, our water use efficiency programs help to achieve the key strategies set forth in our partnership with Sustainable Silicon Valley's Carbon Dioxide Initiative. I am proud to say that our water use efficiency programs have resulted in significant energy savings and air emissions reductions for the county. The environmental benefits resulting from these programs assist in meeting the District's plan for adapting our business practices to consider climate changes in future projects and water supply strategies and in mitigating the physical effects of climate change that may occur in the future.

A handwritten signature in black ink, reading "Stanley M. Williams". The signature is fluid and cursive, with a large, sweeping initial "S".

From the Office of the CEO  
Stanley M. Williams  
Chief Executive Officer  
Santa Clara Valley Water District

# Table of Contents



Santa Clara Valley Water District,  
 Board of Directors,  
 Water Use Efficiency Unit Staff.....ii

From the Office of the CEO.....iii

Executive Summary..... 1  
     Global Climate Change..... 1

About the Santa Clara Valley Water District.....2

The Santa Clara Valley Water District’s  
 Water Use Efficiency Programs .....3  
     Residential Water Conservation Programs.....3  
     Commercial, Industrial, and Institutional  
     Water Conservation Programs.....5  
     Landscape Water Conservation Programs.....5  
     Recycled Water Partnerships.....6  
     Water Use Efficiency Benefits.....6

California’s Water and Energy Nexus.....8  
     Supplying Water is Energy Intensive.....8  
     Air Pollution from Energy Production.....9  
     Carbon Dioxide and  
     Global Climate Change.....9  
     Partnerships Between Water  
     and Energy Professionals.....10  
     The Water to Air Models.....11

Energy Savings and Air Emissions  
 Reductions from Water Conservation  
 and Water Recycling..... 13  
     Energy Savings.....13  
     The Energy Intensity of Water  
     Supply Sources.....16  
     Air Pollutant Emissions Reductions.....17  
     Breakdown of Energy Savings  
     from Water Conservation.....28  
     Potential End Use Energy Savings  
     from Hot Water Conservation.....31  
     Energy Consumption for End Uses.....31  
     Sources of Uncertainty.....31



The Santa Clara Valley Water District:  
 Saving Water, Saving Energy,  
 and Reducing Air Pollution.....33

Findings and Recommendations.....35

Appendix A: Methodology for Estimating  
 Energy Savings and Air Emissions  
 Reductions.....36  
     Water Supply.....36  
     Energy Sources and Factors.....36  
     End Use Energy Estimation.....41  
     Air Emissions Reductions.....42

Notes.....43

## Executive Summary

The Santa Clara Valley Water District (District), the primary water agency for Santa Clara County, which encompasses the southern part of the San Francisco Bay, provides water supplies for an expanding urban population:

- Containing 1.8 million residents
- Hosting 200,000 commuters
- Harboring Silicon Valley, a major economic driver for California

To help meet increasing water demands, the District has developed a comprehensive suite of water conservation and water recycling programs that have resulted in **cumulative savings of 370,000 acre-feet (AF) of new water supplies between fiscal year (FY) 92-93 and FY 05-06**. In addition to saving water, **water conservation and water recycling programs save energy and reduce air pollutant emissions** due to the significant quantities of energy required (and air pollutants generated by energy production) for the water supply chain:

- Water conveyance
- Water treatment
- Distribution
- End use
- Wastewater treatment

Air pollutants generated include (depending on energy source) the following: **reactive organic gases, sulfur oxides, nitrogen oxides, particulate matter, and carbon dioxide**. The latter is a greenhouse gas that contributes to global warming.

### Global Climate Change

The climate changes and other impacts that occur as a result of global warming present challenges for water agencies. Sea level rise (including saltwater intrusion into the freshwater San Francisco Bay-San Joaquin Delta levee system), a decrease in snow pack in the Sierra Nevada mountain range (which supplies water for much of the state), and increased drought are all possible outcomes of global climate change. The District is committed



to responding to these challenges through adaptation (preparing for future changes) and mitigation (reducing the District's role in global warming through more efficient use of resources).

With regard to the mitigation of global climate change, the District recently completed an analysis of the energy saved by its water conservation and water recycling programs, which have been in operation since FY 92-93. **For FY 92-93 through FY 05-06, the District saved approximately 1.42 billion kilowatt-hours (kWh) of energy**, which represents a financial savings of approximately \$183 million and is equivalent to the annual electricity required for 207,000 households. **Through saving energy, the emissions of approximately 335 million kg of carbon dioxide, a greenhouse gas, were eliminated**, which is the equivalent of removing 72,000 passenger cars from the roads for one year. The emissions of several other air pollutants were reduced due to the energy savings from the District's water conservation and water recycling programs (numbers in parentheses are for the FY 92-93 through FY 05-06 time span): reactive organic gases (20,900 kg), nitrogen oxides 146,200 kg), sulfur oxides (13,900 kg), and particulate matter smaller than 10 microns, or PM10 (25,700 kg).

The District is also engaged in several other energy-efficient practices/projects and received certification as a Green Business in 2004.

**A state-of-the-art solar energy project was recently completed at its headquarters campus**, providing approximately 20% of the campus's electricity demands. The District also has a hydroelectric generation facility

located in the county that generates electricity (713,000 kWh for FY 05-06) that is then sold back to the electric grid as a clean source of energy.

## About the Santa Clara Valley Water District

The Santa Clara Valley Water District is the primary water resources agency for Santa Clara County, California. It acts not only as the county's water wholesaler, but also as its flood protection agency and is the steward for its streams and creeks, underground aquifers and District-built reservoirs.

As the county's water wholesaler, the District ensures there is enough clean, safe water for homes, businesses and agriculture. As the agency responsible for local flood protection, the District works diligently to protect Santa Clara Valley residents and business from the devastating effects of flooding.

Our stream stewardship responsibilities include creek restoration and wildlife habitat projects, pollution prevention efforts and a commitment to natural flood protection.





# The Santa Clara Valley Water District's Water Use Efficiency Programs

The Santa Clara Valley Water District, located in San Jose, California, is the water wholesaler for Santa Clara County and serves the area's 15 cities, of which San Jose is the largest, with 1.8 million residents and over 200,000 commuters (Figure 1). **The District meets the county's water demands through a combination of local water supplies** (groundwater, surface water, recycled water, and water conservation) **and imported water supplies** (from the San Francisco Bay-Sacramento Delta through the Central Valley Project and the State Water Project). The San Francisco Public Utilities Commission also provides water to parts of the county via the Hetch Hetchy Aqueduct from the Sierra Nevada mountain range.

The District manages cost-effective innovative programs in water conservation and water recycling and is also exploring the feasibility of several desalination initiatives. The District collaborates with its retailers, local cities, businesses, and the public to implement its water conservation and recycling programs. The District also receives grant funding for its programs, including funds from the California Department of Water Resources.



*The District offers a rebate for high efficiency clothes washers.*



*A Water-Wise House Call technician measures irrigation efficiency.*

Additionally, the District enters into cost-sharing agreements with several regional and local agencies.

**The water supplied through the District's water conservation and water recycling programs has been and continues to be a very important element for meeting the county's water supply demands.**

The District offers both agricultural and urban water conservation programs. The latter category includes

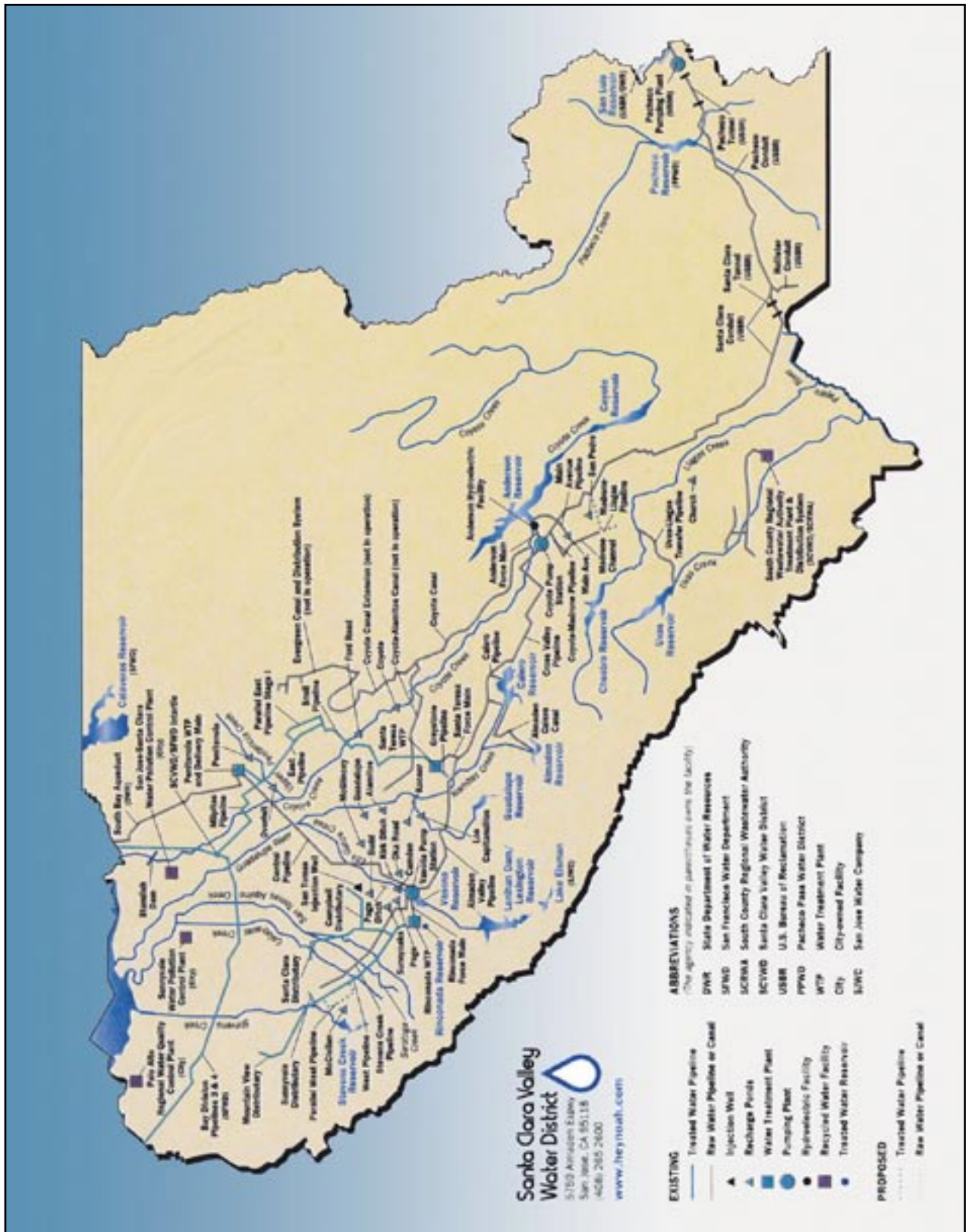
- 1) residential,
- 2) landscape, and
- 3) commercial, industrial, and institutional (CII) water conservation programs.

## **Residential Water Conservation Programs**

The District's flagship residential water conservation program is the Water Wise House Call Program. The Water Wise House Call Program provides a trained water use efficiency expert to inspect all indoor and outdoor water-using devices, install low-flow showerheads, install faucet aerators, replace leaking toilet flappers, and suggest other/ additional ways to improve residential water use



Figure 1 • The District's Water Supply System





efficiency, including improved irrigation system water use efficiency. Other residential water conservation programs include the Residential High-Efficiency Clothes Washer Rebate Program, the Residential High-Efficiency Toilet Rebate Program, and the Residential High-Efficiency Water Softener Rebate Program. The District also provides outreach and educational materials at many community events held throughout Santa Clara County.

### **Commercial, Industrial, and Institutional Water Conservation Programs**

For the CII sector, the District offers the Water Efficient Technologies Program, which offers rebates for any process, technological, or equipment change that conserves water. The Cooling Tower Conductivity Controller Rebate Program is a program designed to improve the water use efficiency of cooling towers. The District also offers a CII survey program where a CII water use efficiency expert inspects water-using devices and equipment at CII sites and recommends water use efficiency improvements. Other CII programs include the CII High-Efficiency Clothes Washer Rebate Program, the CII High-Efficiency Toilet Direct Installation Program, and, for commercial kitchens and restaurants, the High-Efficiency Pre-Rinse Sprayer Direct Installation Program.

### **Landscape Water Conservation Programs**

For the urban sector, landscape water conservation programs include a Weather-Based Irrigation Controller Installation Program, where irrigation controllers are installed to improve overall efficiency of the irrigation system, and a Water-Efficient Landscape Rebate Program, where rebates are provided for the installation of low water-using plants and permeable hardscape (e.g., bark, mulch, rocks, sand). Another landscape water conservation program is the Irrigation Technical Assistance Program/Irrigation System Hardware Retrofit Program, in which a landscape water use efficiency expert inspects a site's irrigation system and recommends (and provides rebates for) water use efficiency improvements.

For the agricultural sector, the District provides a Mobile Lab Program where an agricultural water use efficiency expert provides on-site pump and irrigation system evaluations to farmers to maximize water use efficiency. The District also provides an agricultural irrigation scheduling calculator, offers technical seminars for agriculture professionals, manages a California Irrigation Management Information System (CIMIS) Station, and provides multi-spectral imaging for all large landscape and agricultural areas throughout the county for use in calculating optimal water budgets.



*The District's Mobile Lab Program improves water use efficiency for agricultural lands.*



### Recycled Water Partnerships

As the county’s water manager, the District has partnerships with all four recycled water producers in Santa Clara County:

- The South Bay Water Recycling Program, which operates out of the San Jose/Santa Clara Water Pollution Control Plant,
- The Sunnyvale Water Pollution Control Plant,
- The South County Regional Wastewater Authority in Gilroy, and
- The Palo Alto Regional Water Quality Control Plant.

In addition to some development of recycled water infrastructure throughout Santa Clara County, the District executes innovative studies regarding advanced treatment technologies for recycled water, recycled water release/use issues, economic valuation of and public perceptions regarding recycled water, and recycled water quality.

In terms of evaluating another global-warming-proof supply, the District has a partnership with three other Bay Area water agencies to explore the feasibility of a regional desalination facility. This project is studying desalination of brackish water, San Francisco Bay water, and/or ocean water for an optimal regional facility to serve these agencies and more than 5.4 million people.

### Water Use Efficiency Benefits

The District’s comprehensive suite of programs helps to reduce the demand on existing water supplies as well as delay or eliminate the need for new water supplies, thereby helping to meet the water demands of an expanding population (Figure 2). Since the District’s **water conservation programs** began in FY 92-93, these programs have **cumulatively saved approximately 300,000 AF of water** while the District’s **water recycling programs**, in place since FY 98-99, **have cumulatively saved approximately 68,200 AF of water** (Figure 3). For FY 05-06 alone, water conservation program savings were approximately 39,000 AF while water

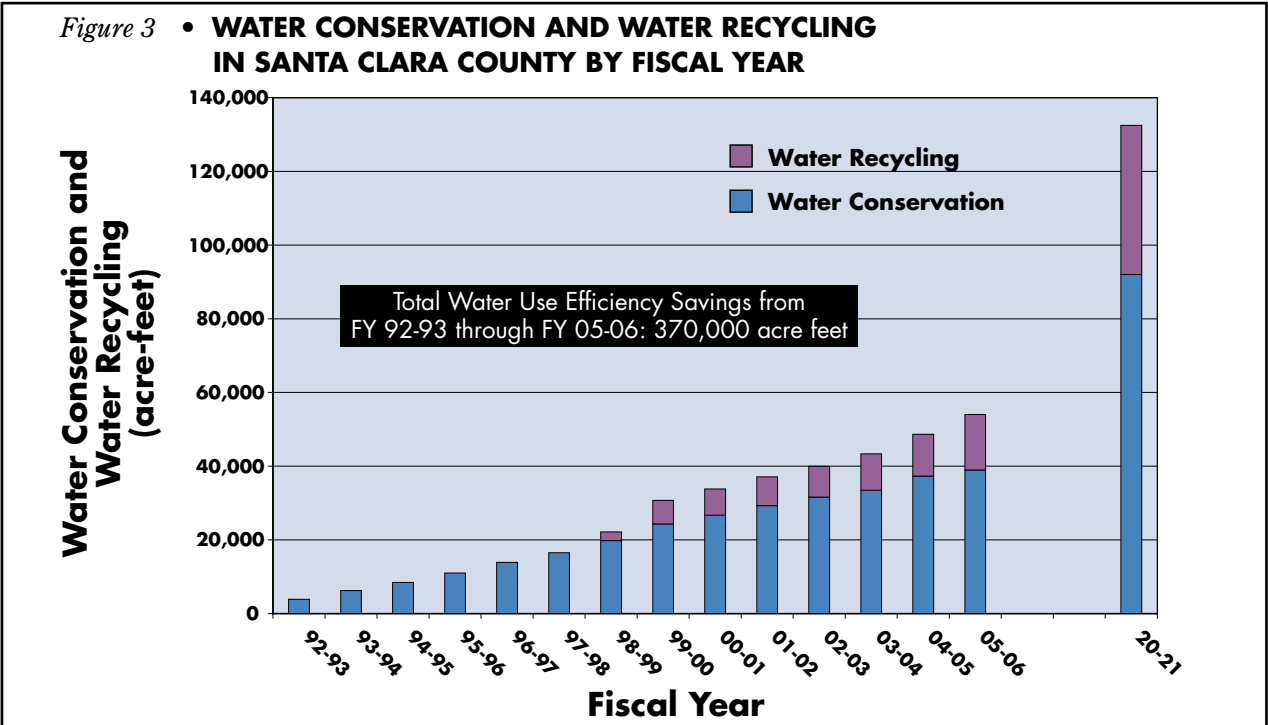
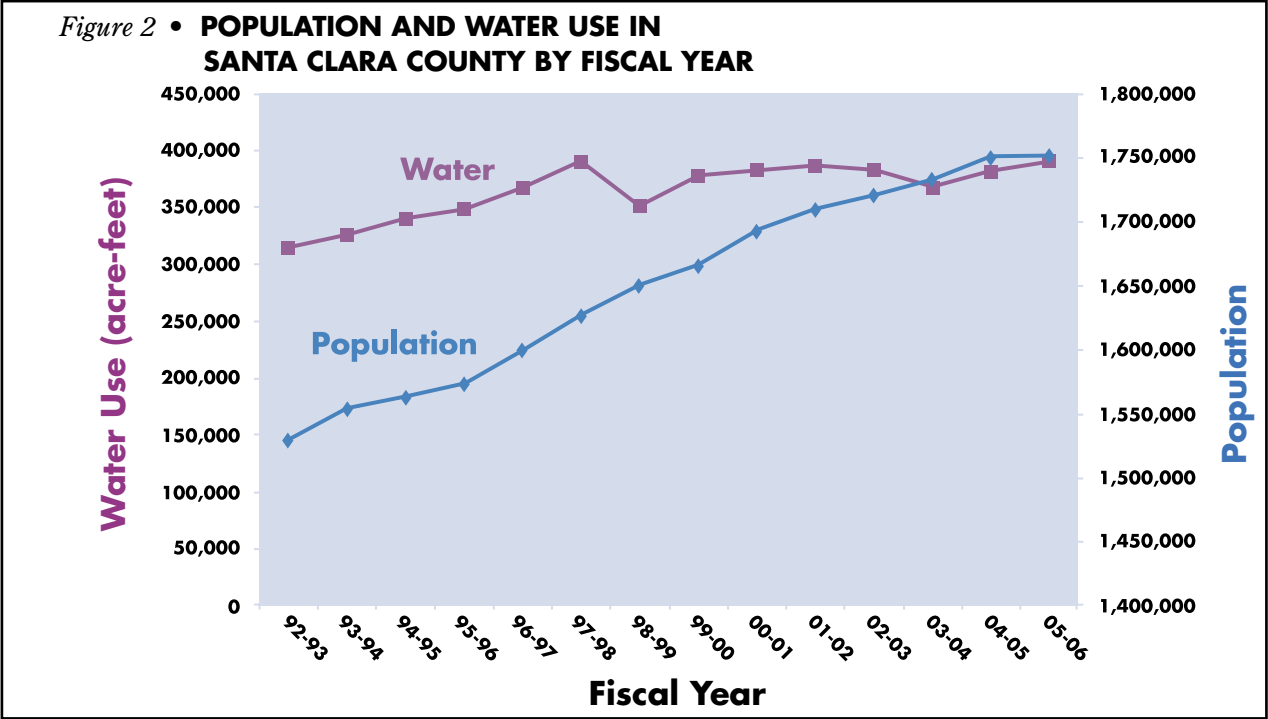


*Recycled water pipeline*

recycling program savings were approximately 15,000 AF (Figure 3). **The combined water supply/demand management provided by water recycling and water conservation met approximately 15% of FY 05-06 total water use in Santa Clara County.**<sup>1</sup>

Besides the water supply management benefits of greater flexibility and increased reliability conferred by the District’s water use efficiency programs, these programs provide environmental benefits by helping to protect the South San Francisco Bay salt marsh habitat, local groundwater supplies, local surface water supplies, and the associated watersheds. The environmental benefits in turn provide significant aesthetic and human health benefits. The District’s water use efficiency programs also help to meet the District’s mission of providing “watershed stewardship and comprehensive management of water resources in a practical, cost-effective, and environmentally sensitive manner.”<sup>2</sup>

The District’s long-term water supply planning combines integrated water resources planning with watershed stewardship. The District Board’s Ends Policies and the District’s 2005 Urban Water Management Plan **establish goals for the water conservation programs and water recycling programs to continue to expand, with water conservation supplying 92,000 AF by the year 2020 and water recycling supplying 10% of total water use (i.e., recycled water supply is estimated to be 40,500 AF) by the year 2020.**



## California's Water and Energy Nexus



### Supplying Water is Energy Intensive

While the primary goal of the District's Water Use Efficiency programs is to use water more efficiently, ancillary benefits include energy savings and the resultant air quality benefits. The latter arise because **California's water supply chain**, or the route water follows as it is pumped and/or conveyed from its source, treated to drinking water standards, distributed, used, and treated to wastewater standards, **is energy intensive** (Figure 4). More specifically, water-related energy consumption in the state represents approximately 15%-20% of all energy consumed in California.<sup>3</sup> For example, **the State Water Project alone**, a 444-mile long aqueduct transporting San Francisco Bay-San Joaquin Delta water to Southern California, **consumes 2%-3% of all electricity in the state** because of the high elevations and long distances over which water must be pumped and conveyed.<sup>4</sup> Thus, a reduction in flow through the water supply chain brought about by an alternative water supply source such as water conservation or water recycling will decrease energy use.<sup>5</sup>

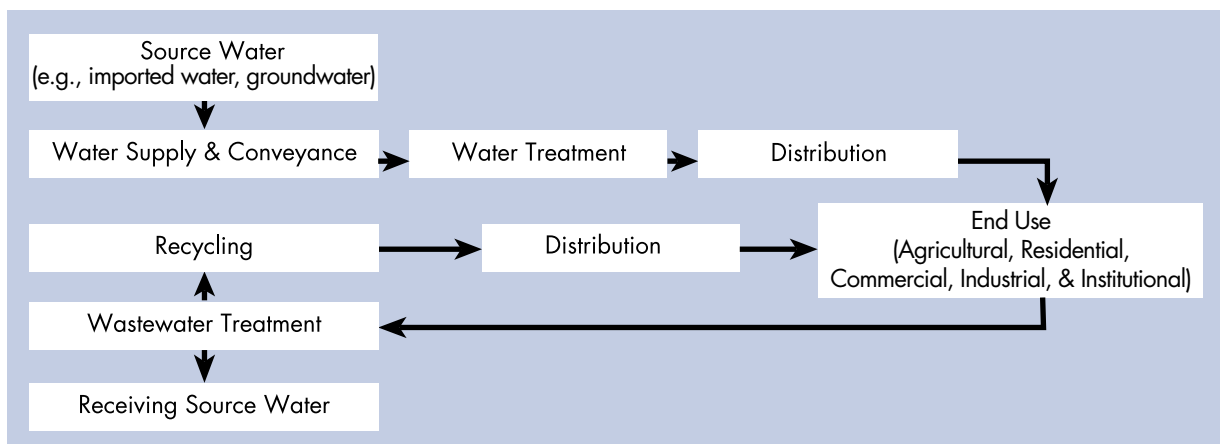


*The water supply chain is energy intensive.*

In general, the energy required for water conveyance and for end use consumes the largest proportion of energy when compared to the other steps in the water supply chain (33% and 56%, respectively, based on a recent case study of San Diego County Water

Authority).<sup>6</sup> Among water-related energy demands at the end use step, energy for heating water represents the largest category. Energy is also used at the end use step for cooling, pumping, and purifying water, especially in the CII sector.<sup>7</sup> Therefore, in

**Figure 4 • THE WATER SUPPLY CHAIN IS ENERGY INTENSIVE**





addition to saving energy by reducing water flow through the water supply chain, water conservation also has the potential to save energy at the end use step by reducing the energy demand for heating, purifying, cooling, and/or pumping water, depending on the end use device (e.g., water-efficient clothes washers reduce the energy required for heating water while water-efficient industrial cooling systems reduce the energy required for cooling water).<sup>8</sup>

### Air Pollution from Energy Production

Electricity production by power plants using non-renewable energy sources such as natural gas and coal generates air pollutants. Thus, a reduction in water-related energy demand due to water conservation and water recycling leads to a reduction in emissions of air pollutants.<sup>9,10</sup> **Air pollutants**<sup>11</sup> generated by power plants using non-renewable energy sources **include reactive organic gases, particulates, carbon dioxide, sulfur oxides, and nitrogen oxides, all of which have adverse human health and/or environmental impacts.**<sup>12</sup> Particulate matter, especially PM10 (particulate matter smaller than ten microns), because of its ability to penetrate into the deepest parts of the lungs, can lead to asthma, bronchitis, other lung diseases, immune system damage, and organ damage.<sup>13</sup> Reactive organic gases and sulfur oxides also have adverse health effects, including organ damage, birth defects, and cancer.<sup>14</sup> Reactive organic gases and nitrogen oxides contribute to smog formation (of which ozone is a major component) while nitrogen oxides and sulfur oxides contribute to acid rain deposition.<sup>15</sup>

### Carbon Dioxide and Global Climate Change

Carbon dioxide is a greenhouse gas and plays a role in global climate change. Thus, there is a direct connection between water supply and global climate change.<sup>16</sup> Global warming and the climate changes that may occur as a result of global warming present many challenges for water agencies because it is predicted that Northern California's water supply system will likely change in several ways. First, sea level rise in the San Francisco Bay, brought about by melting of the world's glaciers and polar ice caps, will lead to saltwater intrusion into local groundwater

basins and the freshwater San Francisco Bay-San Joaquin Delta levee system.<sup>17</sup> Sea level rise will also lead to increased coastal flooding.<sup>18</sup> Second, the snow pack in the Sierra Nevada mountain range will likely decrease due to increased air temperatures, with the remaining snow pack melting earlier in the season; both of these changes may lead to decreases and changes in the pattern of springtime runoff.<sup>19</sup> The net effect may be to decrease the volume of water available for export to Santa Clara County, among other regions in California. Third, precipitation patterns are expected to change, with more extremes and a shorter, more intense rainy season.<sup>20</sup> These changes in precipitation patterns, combined with an earlier snowmelt, may lead to increased late winter/early springtime flooding and may overwhelm the already fragile (i.e., in need of standard maintenance, repairs, and upgrades) San Francisco Bay-San Joaquin Delta levee system as well as the District's local supply systems.<sup>21</sup> Finally, increased droughts may occur as well, either seasonally, inter-yearly, or both.<sup>22</sup> **The District is committed to responding to these challenges through adaptation (preparing for future changes) and mitigation (reducing the District's role in global warming through more efficient use of resources). Water conservation and water recycling play a large role in the District's adaptation and mitigation efforts.**



*Climate change will likely impact California's water supply system.*

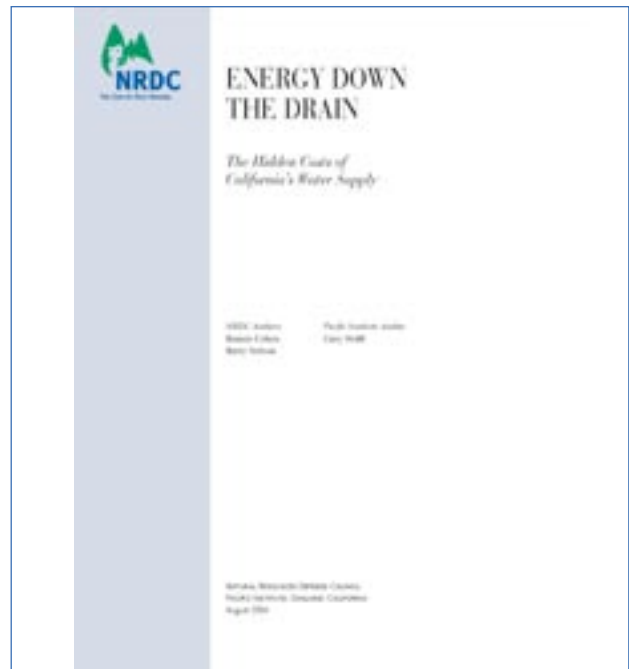


## Partnerships Between Water and Energy Professionals

The challenges posed by global climate change have brought together professionals from both the water and energy industries with the shared goal of understanding the connections between water and energy in California’s water supply system. In 2004, the Pacific Institute and the Natural Resources Defense Council released a report, “Energy Down the Drain: The Hidden Costs of California’s Water Supply,” which investigated and quantified the energy implications of water management decisions for two agricultural case studies and for one urban case study.<sup>23</sup> **This analysis determined that water conservation and water recycling offer significant energy savings and air quality benefits** when compared to other water supply sources, recommending that water and energy policymakers consider the energy implications of water policy decisions.<sup>24</sup> It was also recommended that water and energy policymakers prioritize water conservation, as water conservation has the potential to save more energy (and thus reduce the emissions of more air pollutants) than any other demand management measure/water supply source.<sup>25</sup>

Towards these ends, “Energy Down the Drain” suggested a number of specific actions, including

1. the modification of California’s state planning tools such as the Urban Water Management Planning Act and the Department of Water Resources’ Bulletin 160 to require explicit accounting of energy costs and benefits of water supply options;
2. greater coordination among the state’s resource management agencies for improved integration of energy and water policy;
3. prioritization at the state level for water conservation funding (for water conservation incentives);



For a full copy of the report, visit the website: [www.pacinst.org](http://www.pacinst.org)

4. greater enforcement of current conservation requirements as well as the development of new conservation requirements, including conservation-oriented water rate structures and water metering; and
5. the development of methods and approaches to maintain/enforce water conservation savings.<sup>26</sup>

More recently, the California Energy Commission released “California’s Water-Energy Relationship,” a report investigating the energy requirements of California’s water supply system, future energy demands on the water supply system, and the role of water use efficiency and energy efficiency for using both resources more efficiently.<sup>27</sup> The report found that

1. electricity use in the water sector could almost double by year 2015;
2. there are significant data gaps that may lead to an underestimation of energy use, particularly for the agricultural sector and for groundwater pumping;





3. an extended drought or a shift from snow to rain (as may be caused by an increase in global temperature) would greatly increase water-related energy use;
4. water conservation (and water recycling to a lesser extent) has the potential to significantly reduce water-related energy use; and finally
5. investor-owned energy utilities are neither credited nor funded for the energy savings that result from water conservation.<sup>28</sup>

To address these findings, the report recommended increased collaboration between the California Energy Commission and the California Department of Water Resources (and between the water industry and the energy industry more generally) to share

information, identify funding opportunities, provide technical support, and develop policies that better integrate energy considerations into water supply management.<sup>29</sup>

With an eye towards collaboration, in August 2005 the District enlisted the support of the California Department of Water Resources to co-host an “Energy Workshop for Water and Wastewater Agencies” at the District to explore the connections between water and energy and to identify strategies for conserving energy in water supply and wastewater treatment operations. In addition to serving as a forum for sharing information, practices, and technologies, this successful workshop has brought about several ongoing collaborations between water and wastewater utilities.<sup>30</sup>



*Energy–Water workshop held at District in August 2005.*



## The Water to Air Models

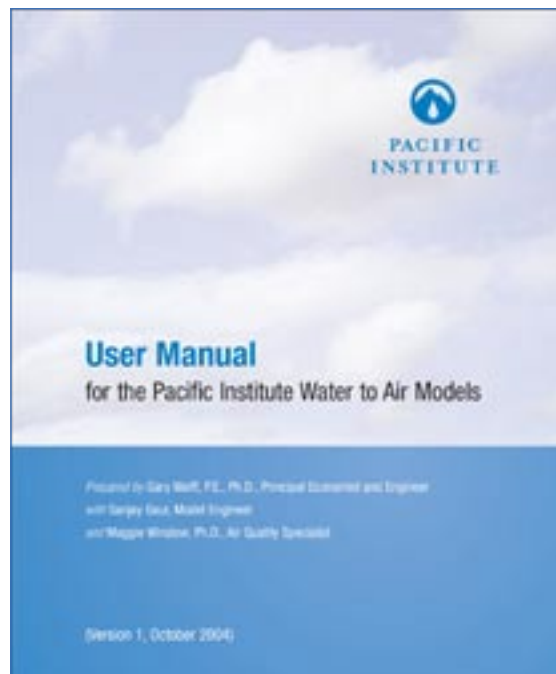
The initial approach for quantifying the energy embedded<sup>31</sup> in California’s water supply system was developed by Bob Wilkinson from the University of California, Santa Barbara (for the California Institute for Energy Efficiency) and was expanded upon by Gary Wolff of the Pacific Institute into the spreadsheet-based “Water to Air Models.”<sup>32, 33</sup> The model’s whole-systems approach for quantifying water-related energy use provides water supply planners with an overview of the energy intensity of different water supply options, allowing for the comparison of water supply scenarios. Users can input agency- (or region-) specific water supply, energy use, and air emissions information or, alternatively, the model has default values that can be used. **District staff used the Water to Air Model to quantify the energy savings and air pollutant emissions reductions garnered by the District’s water conservation and water recycling programs.** Desalination

was not investigated as it is not currently a water supply source for the District.

To determine energy savings and air emissions reductions, two scenarios were compared:

1. Water conservation and water recycling are present (reflects current conditions); and
2. The volume of water supplied by water conservation and water recycling is now supplied by imported water, an alternative supply source.

These two scenarios were compared for each fiscal year from FY 92-93 through FY 05-06 and for FY 20-21. A discussion of the methodology used for this analysis is described in Appendix A; further information regarding the Pacific Institute’s Water to Air Model can be found in the model’s user manual.<sup>34</sup>



For a full copy of the manual, visit the website: [www.pacinst.org](http://www.pacinst.org)



# Energy Savings and Air Emissions Reductions From Water Conservation and Water Recycling

## Energy Savings

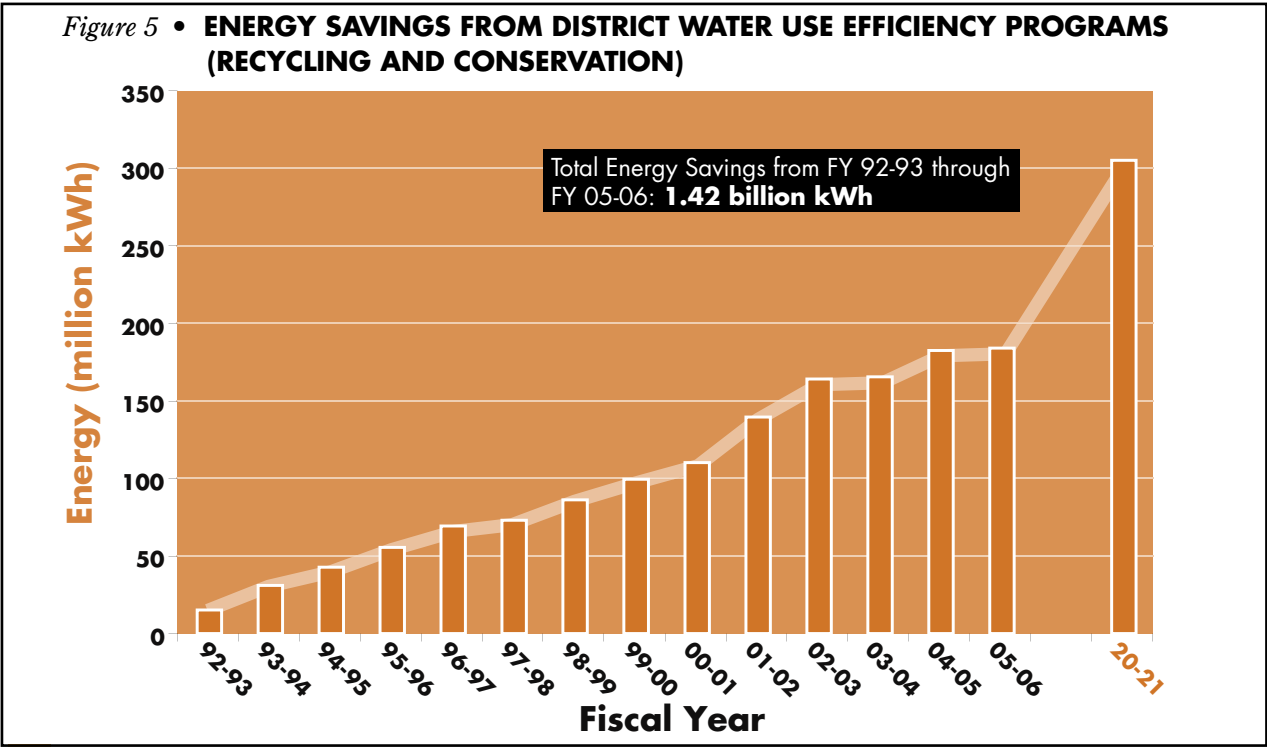
The results of the Water to Air model show that the District has achieved significant energy savings and air emissions reductions since the inception of its water conservation and water recycling programs. Energy savings data are presented in Figures 5 through 9 while air emissions reductions are presented in Figures 11 through 35. Table 1 summarizes the results for the FY 92-93 through FY 05-06 time span. **Energy savings resulting from the District’s water conservation and water recycling programs were estimated to be approximately 1.42 billion kWh for FY 92-93 through FY 05-06**, the time span during which the programs have been operational (Figure 5). For comparison, 1.42 billion kWh is equivalent to the electricity required for 207,000 households for one year, representing a savings of \$183 million (in 2006 dollars).<sup>35</sup> During FY 05-06 alone, energy savings from the District’s water conservation and water recycling programs were approximately 184 million kWh (Figure 5), representing a savings of \$24 million (in 2006 dollars). Projected energy savings for FY 20-21, which are based on projected water conservation savings and water recycling estimates for FY 20-21, will be approximately 305 million kWh (Figure 5), representing a savings of \$40 million (in 2006 dollars).

**Of these energy savings numbers, on average approximately 60% of the savings are due to end use energy savings while the remaining 40% of the energy savings are due to the other four steps in the water supply chain: supply/conveyance, treatment, distribution, and wastewater treatment.**

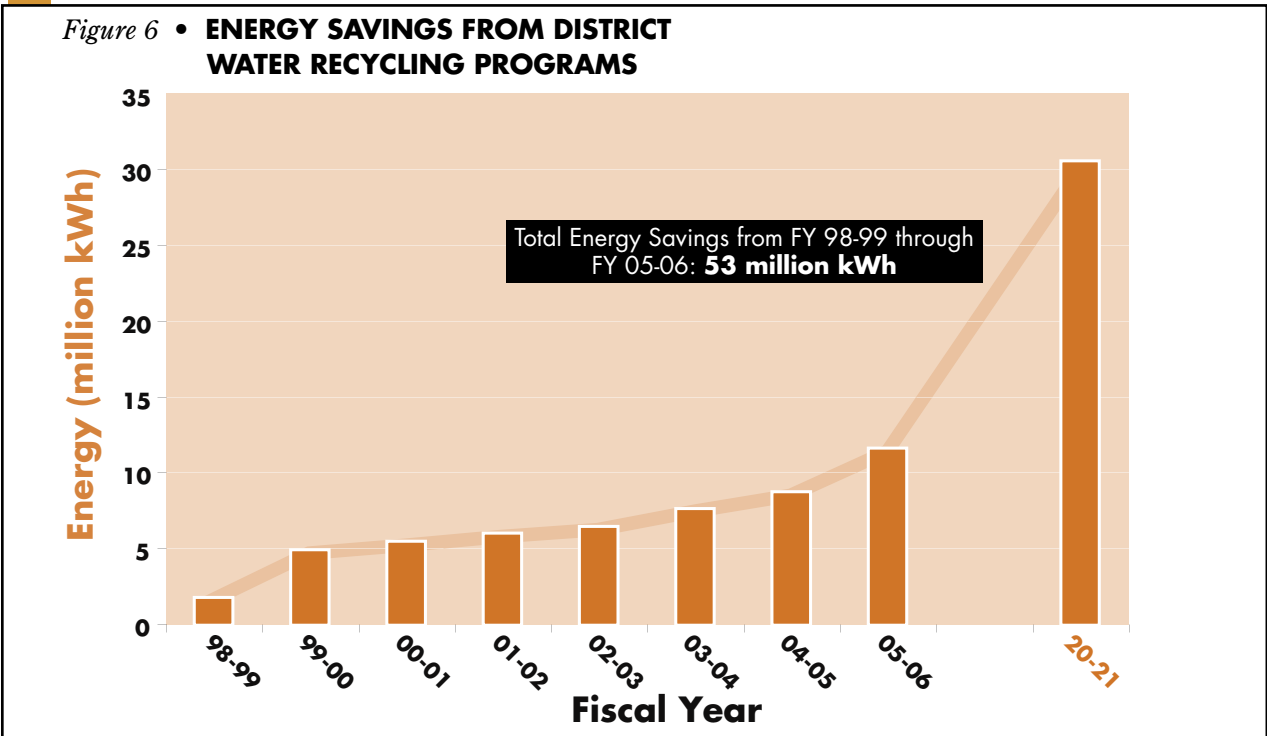
Energy savings can be partitioned into energy savings due to water conservation programs and energy savings due to water recycling programs. **For FY 92-93 through FY 05-06, energy savings due to water recycling were approximately 53 million kWh (Figure 6) while energy savings due to water conservation were approximately 1.36 billion kWh (Figure 7).** A breakdown of energy savings due to urban water conservation relative to agricultural water conservation is shown in Figures 8 and 9. **For FY 92-93 through FY 05-06, energy savings due to urban water conservation were approximately 1.35 billion kWh (Figure 8) while energy savings due to agricultural water conservation were approximately 17 million kWh (Figure 9).**

**Table 1 • SUMMARY OF ENERGY SAVINGS AND AIR POLLUTANT EMISSIONS REDUCTIONS FROM DISTRICT WATER CONSERVATION AND WATER RECYCLING PROGRAMS FOR FY 92-93 THROUGH FY 05-06**

Energy Savings (kWh)	1.42 billion
Carbon Dioxide (kg)	335 million
Nitrogen Oxides (kg)	146,200
Sulfur Oxides (kg)	13,900
Reactive Organic Gases (kg)	20,900
PM10 (kg)	25,700



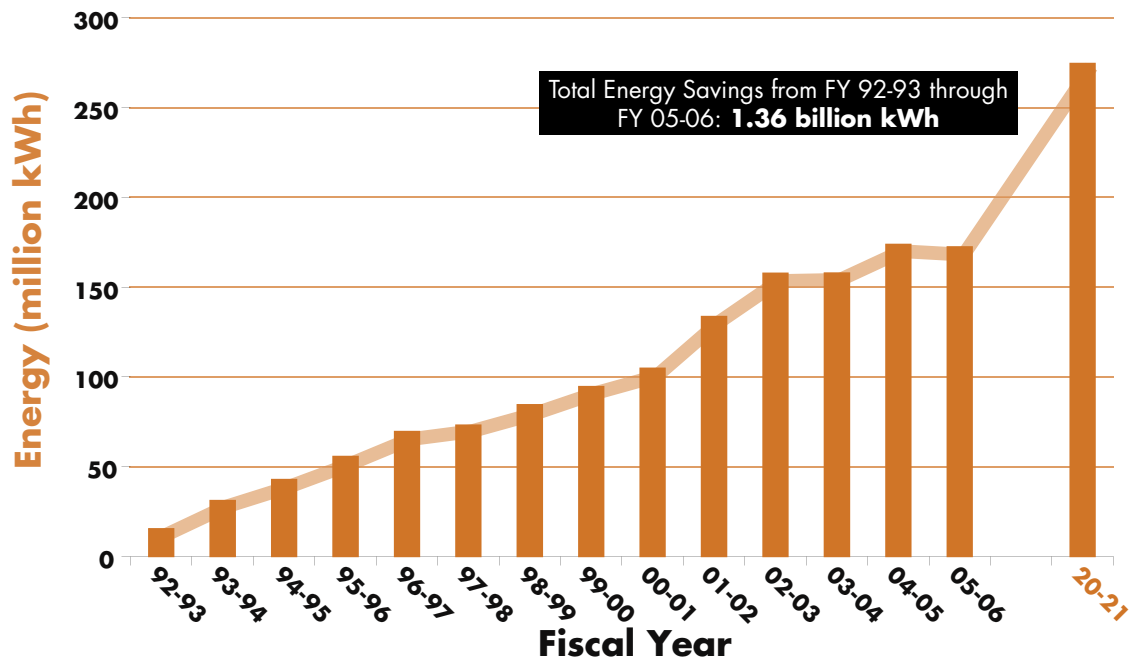
**Figure 5** – The District’s water use efficiency programs significantly reduced energy consumption over the FY 92-93 through FY 05-06 time span, with an estimated total energy savings of 1.42 billion kWh (184 million kWh for FY 05-06) and a forecasted energy savings for FY 20-21 of 305 million kWh.



**Figure 6** – The District’s water recycling programs led to an energy savings of 53 million kWh over the FY 92-93 through FY 05-06 time span, with an energy savings of 12 million kWh for FY 05-06 and a forecasted energy savings of 31 million kWh for FY 20-21.

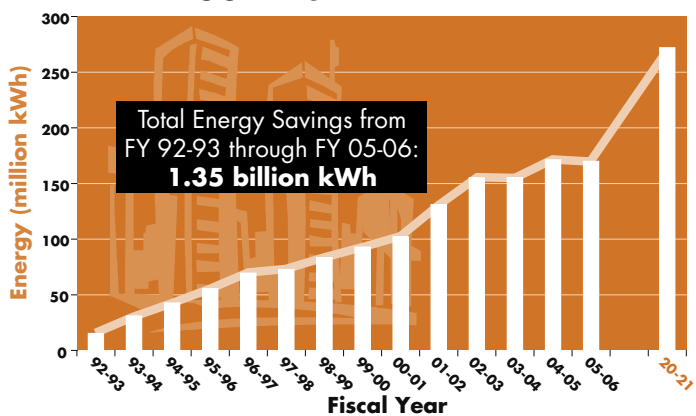


**Figure 7 • ENERGY SAVINGS FROM DISTRICT WATER CONSERVATION PROGRAMS**



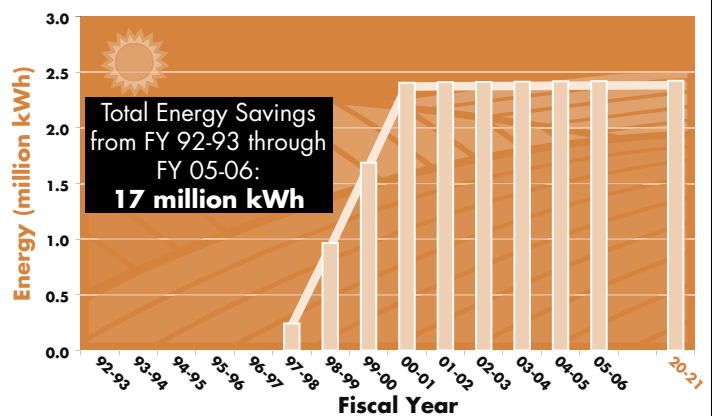
**Figure 7 –** The District’s water conservation programs led to an energy savings of 1.36 billion kWh over the FY 92-93 through FY 05-06 time span, with an energy savings of 172 million kWh for FY 05-06 and a forecasted energy savings of 274 million kWh for FY 20-21.

**Figure 8 • ENERGY SAVINGS FROM DISTRICT URBAN WATER CONSERVATION PROGRAMS**



**Figure 8 –** The District’s urban water conservation programs led to an energy savings of 1.35 billion kWh over the FY 92-93 through FY 05-06 time span, with an energy savings of 170 million kWh for FY 05-06 and a forecasted energy savings of 272 million kWh for FY 20-21.

**Figure 9 • ENERGY SAVINGS FROM DISTRICT AGRICULTURAL WATER CONSERVATION PROGRAMS**



**Figure 9 –** The District’s agricultural water conservation programs led to an energy savings of 17 billion kWh over the FY 92-93 through FY 20-21 time span, with an energy savings of 2 million kWh for FY 05-06 and a forecasted energy savings of 2 million kWh for FY 20-21.



## The Energy Intensity of Water Supply Sources

Figures 5 through 9 demonstrate that water conservation and water recycling save energy when compared to imported water. Another approach to understanding the relative energy intensities of different water supply sources is to use energy factors, which are a ratio of energy consumed to water “processed” (e.g., conveyed, pumped, treated) and are expressed in kWh/AF (see further discussion of energy factors in Appendix A), to estimate the energy embedded in a unit of water. Excluding energy used for end uses, water conservation is the lowest with a value of “0” (i.e., water not used does not enter the energy-consuming water supply chain), local surface water is the next lowest, followed by ground water, recycled water, and imported water (Figure 10).<sup>36</sup> These numbers include energy factors (with the exceptions stated in the notes section) for the following steps in the water supply chain:

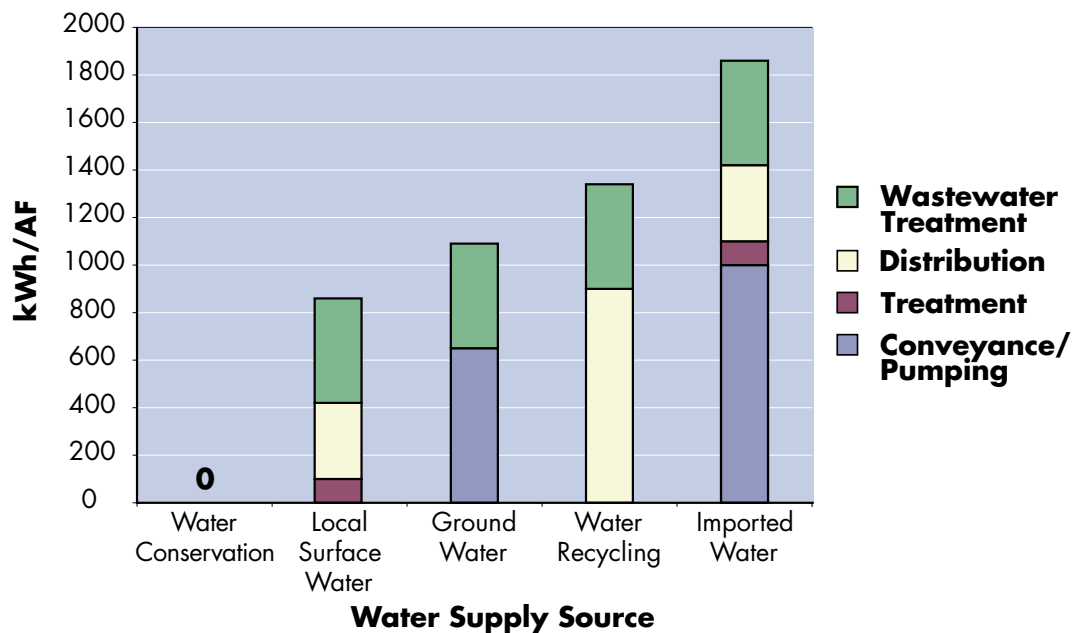
- 1) Source and conveyance,
- 2) Treatment,
- 3) Distribution, and
- 4) Wasterwater treatment.

They do not include the end-use energy factor.

It should be noted that the energy intensity of recycled water will decrease in the future because the county’s largest recycled water producer, South Bay Water Recycling at the San Jose/Santa Clara Water Pollution Control Plant, has recently completed several system improvements, including added storage capacity and improved pump efficiencies; current estimates suggest energy efficiency improvements of approximately 30-35%. Therefore, the estimates of energy savings and air pollution emissions reductions for recycled water for FY 20-21 may be greater than estimated.

Including energy used for end uses would increase the embedded energy of different water supply sources significantly. However, because of the variability among different end uses with respect to energy use (e.g., 67,700 kWh/AF for heating water for dishwashers vs. 800 kWh/AF for heating industrial process water), it is hard to determine an “average” end use value; 12,700 kWh/AF is the weighted average for end use based on the urban case study data used to derive default values for the Water to Air models.<sup>37</sup>

Figure 10 • ENERGY FACTORS FOR DISTRICT WATER SUPPLY SOURCES





### Air Pollutant Emissions Reductions

When compared to energy savings, air pollutant emissions reductions are similarly significant. Figures 11 through 15 show the emissions reductions of carbon dioxide. **For FY 92-93 through FY 05-06, the emissions of approximately 335 million kg of carbon dioxide were avoided as a result of the District’s water conservation and water recycling programs (Figure 11).** For comparison, 335 million kg of carbon dioxide is equivalent to the removal of 72,000 passenger-cars from the roads for one year or to the carbon sequestration by 280,000 acres of conifer forests over the course of one year.<sup>38</sup> For FY 05-06 the emissions of approximately 44 million kg of carbon dioxide were avoided while projected carbon dioxide emissions reductions for FY 20-21 will be approximately 72 million kg (Figure 11). The breakdown of carbon dioxide emissions reductions between water recycling and water conservation as well as between urban water conservation and agricultural water conservation is shown in Figures 12 through 15.

Thus, in the absence of the District’s water conservation and water recycling programs the “carbon footprint” (i.e., the total output of carbon dioxide) of the District’s water supply portfolio would be significantly greater because a water supply source with a higher energy intensity and



*Coal-fired power plants generate air pollutants.*

thus higher associated air pollutant emissions would be supplied in place of water conservation and water recycling programs.

Figures 16 through 35 show the emissions reductions of four other air pollutants:

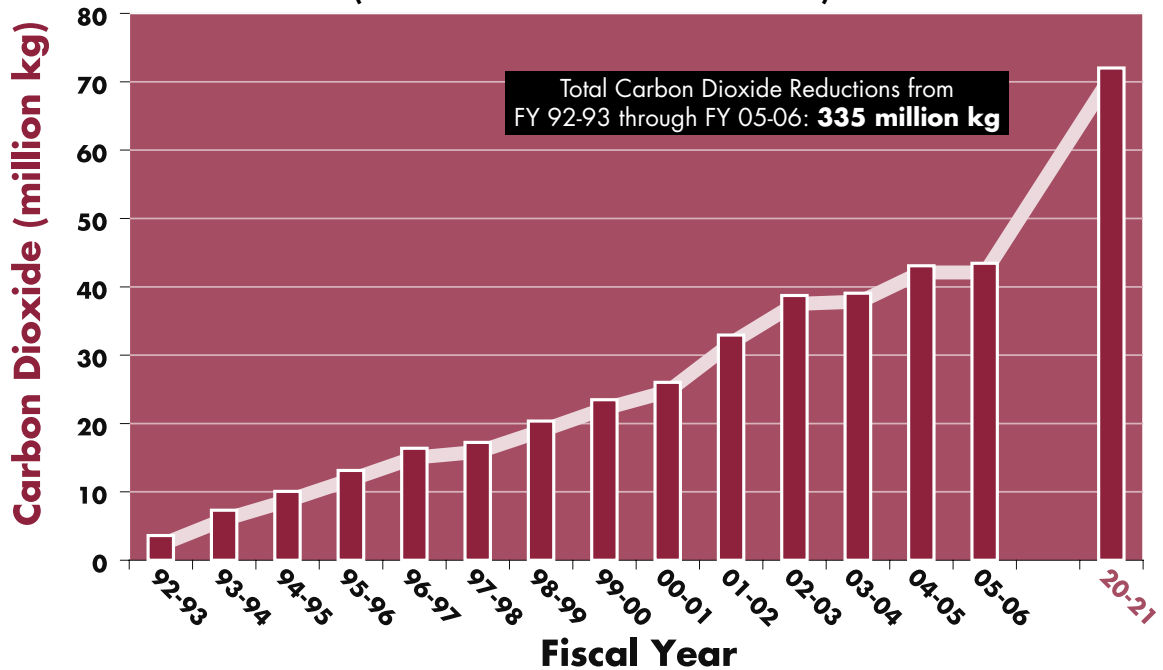
- Reactive organic gases,
- Nitrogen oxides,
- Sulfur oxides, and
- PM10

The breakdown between water recycling and water conservation as well as between urban water conservation and agricultural water conservation is shown for each air pollutant. As is the case for energy and carbon dioxide, the District’s water use efficiency programs resulted in significant reductions in the emissions of these five air pollutants. For a sense of scale, the Bay Area Air Quality Management District imposes fees on annual emissions of nitrogen oxides, sulfur oxides, PM10, and organic gases in excess of 50 tons (45,360 kg) while the South Coast Air Quality Management District in Southern California has more stringent requirements: fees are imposed on annual emissions in excess of 4 tons (3,629 kg).<sup>39, 40</sup>

It is worth noting that the air emissions reduction data presented in Figures 11 through 35 assume that water neither conserved nor recycled but instead supplied by imported water (an assumption of all scenarios, see appendix A) would be subject to the same energy portfolio (i.e., mix of energy sources) as the volume of imported water currently supplied. It may be the case, however, that the energy required to provide the additional volume of imported water (to replace water formerly supplied by water conservation and water recycling) would be purchased on the margin from a power source on the open market with higher emissions factors than the air emissions factors of the current energy portfolio. Thus, the air quality benefits of the District’s water conservation and water recycling programs may be greater than estimated in this analysis.<sup>41</sup>

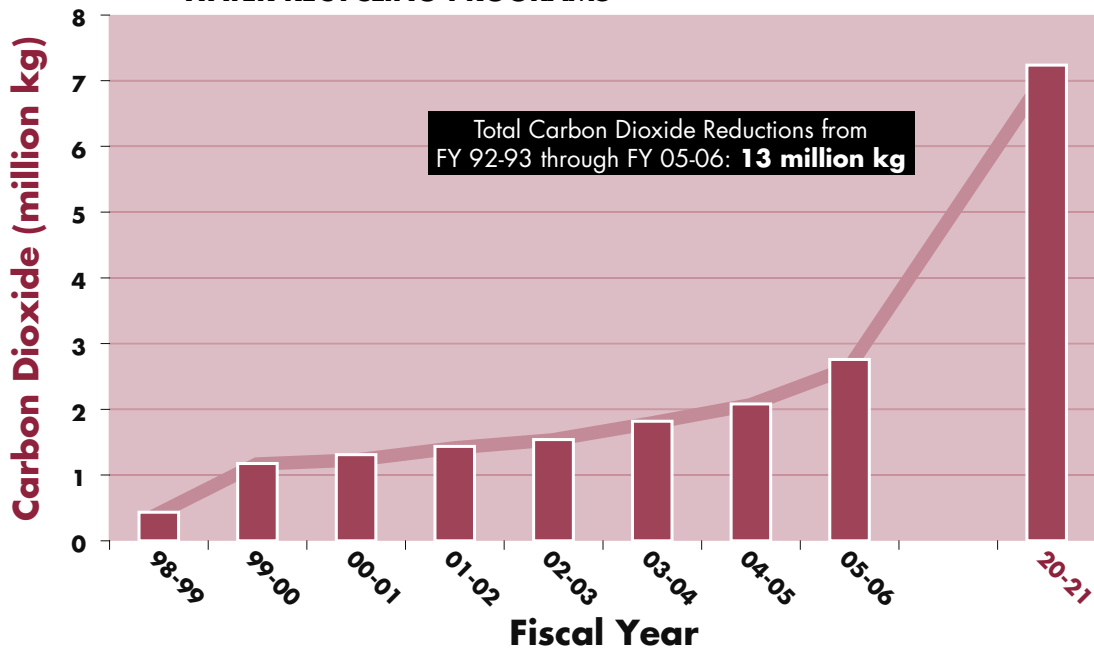


**Figure 11 • REDUCTION OF CARBON DIOXIDE BY DISTRICT WATER USE EFFICIENCY PROGRAMS (RECYCLING AND CONSERVATION)**



**Figure 11** – The District’s water use efficiency programs significantly decreased emissions of carbon dioxide over the FY 92-93 through FY 05-06 time span, with an estimated total emissions reduction of 335 million kg (43 million kg for FY 05-06) and a forecasted reduction for FY 20-21 of 72 million kg.

**Figure 12 • REDUCTION OF CARBON DIOXIDE BY DISTRICT WATER RECYCLING PROGRAMS**

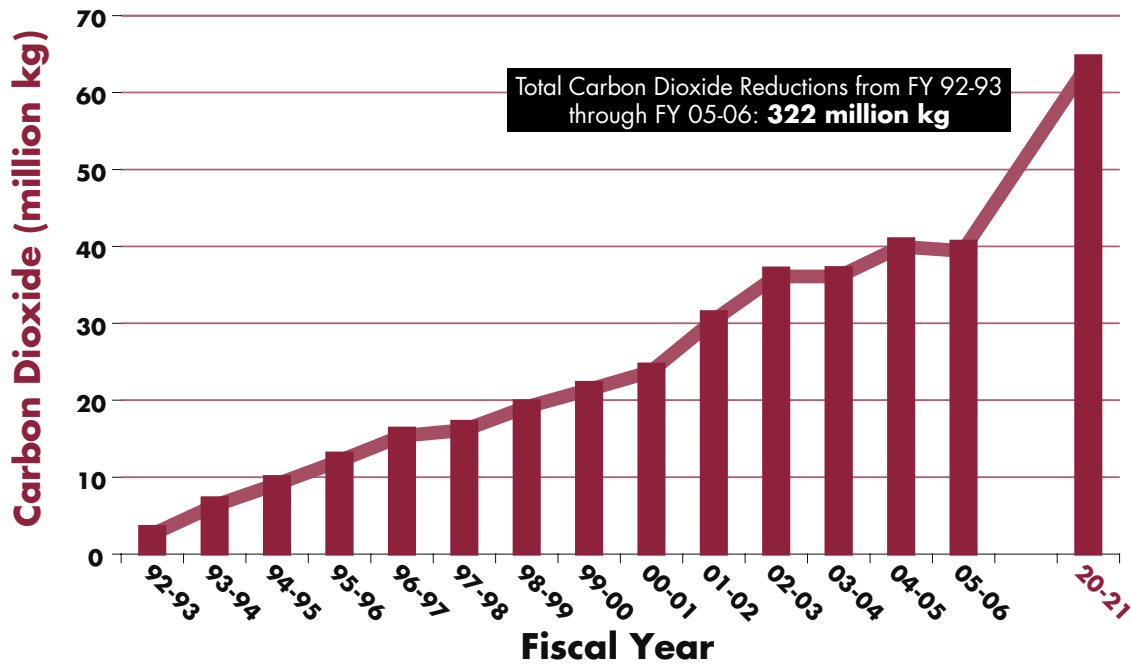


**Figure 12** – The District’s water recycling programs led to a reduction of 13 million kg of carbon dioxide over the FY 92-93 through FY 05-06 time span, with a reduction of 3 million kg for FY 05-06 and a forecasted reduction of 7 million kg for FY 20-21.



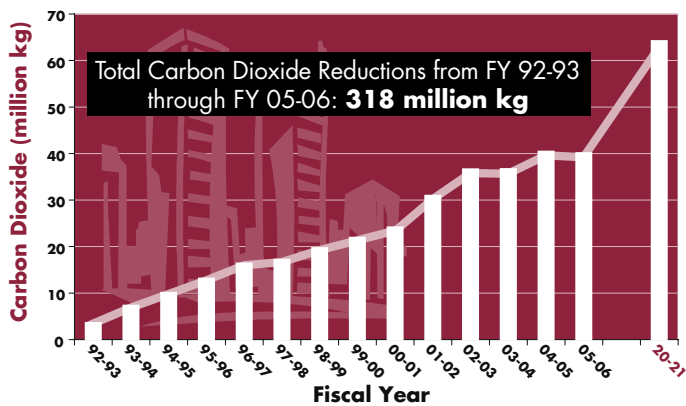


**Figure 13 • REDUCTION OF CARBON DIOXIDE BY DISTRICT WATER CONSERVATION PROGRAMS**



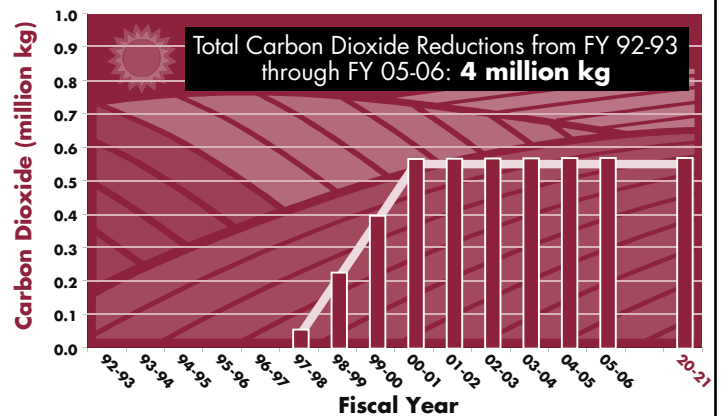
**Figure 13** – The District’s water conservation programs led to a reduction of 322 million kg of carbon dioxide over the FY 92-93 through FY 05-06 time span, with a reduction of 41 million kg for FY 05-06 and a forecasted reduction of 65 million kg for FY 20-21.

**Figure 14 • REDUCTION OF CARBON DIOXIDE BY DISTRICT URBAN WATER CONSERVATION PROGRAMS**



**Figure 14** – The District’s urban water conservation programs led to a reduction of 318 million kg of carbon dioxide over the FY 92-93 through FY 05-06 time span, with a reduction of 40 million kg for FY 05-06 and a forecasted reduction of 64 million kg for FY 20-21.

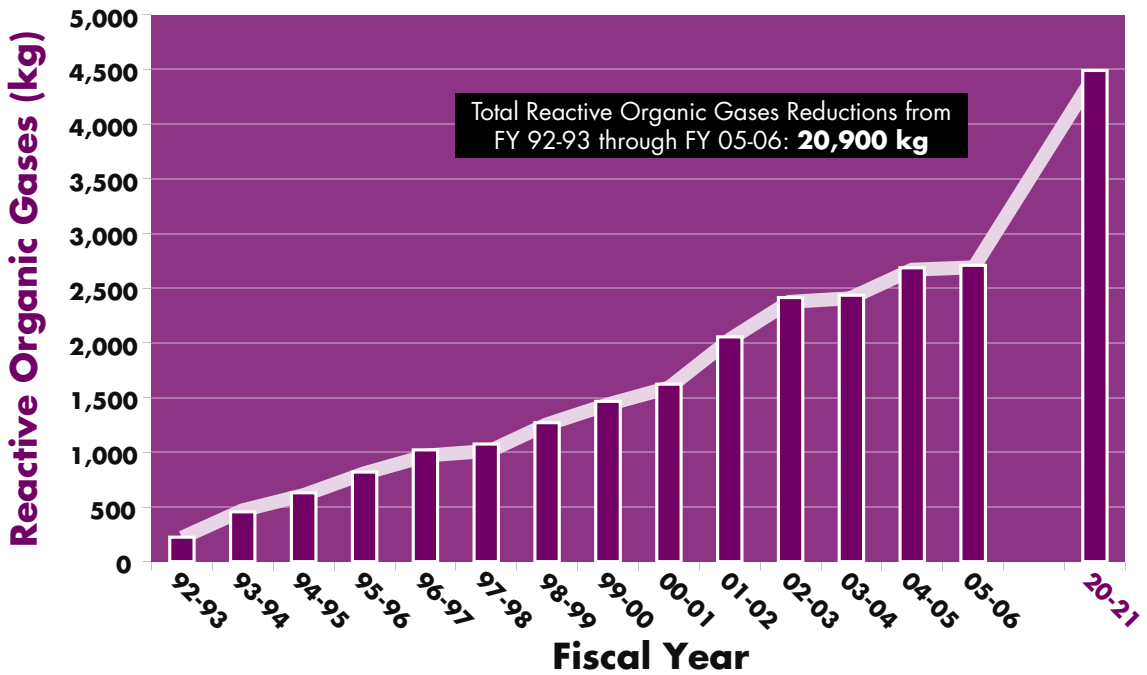
**Figure 15 • REDUCTION OF CARBON DIOXIDE BY DISTRICT AGRICULTURAL WATER CONSERVATION PROGRAMS**



**Figure 15** – The District’s agricultural water conservation programs led to a reduction of 4 million kg of carbon dioxide over the FY 92-93 through FY 20-21 time span, with a reduction of 1 million kg for FY 05-06 and a forecasted reduction of 1 million kg for FY 20-21.

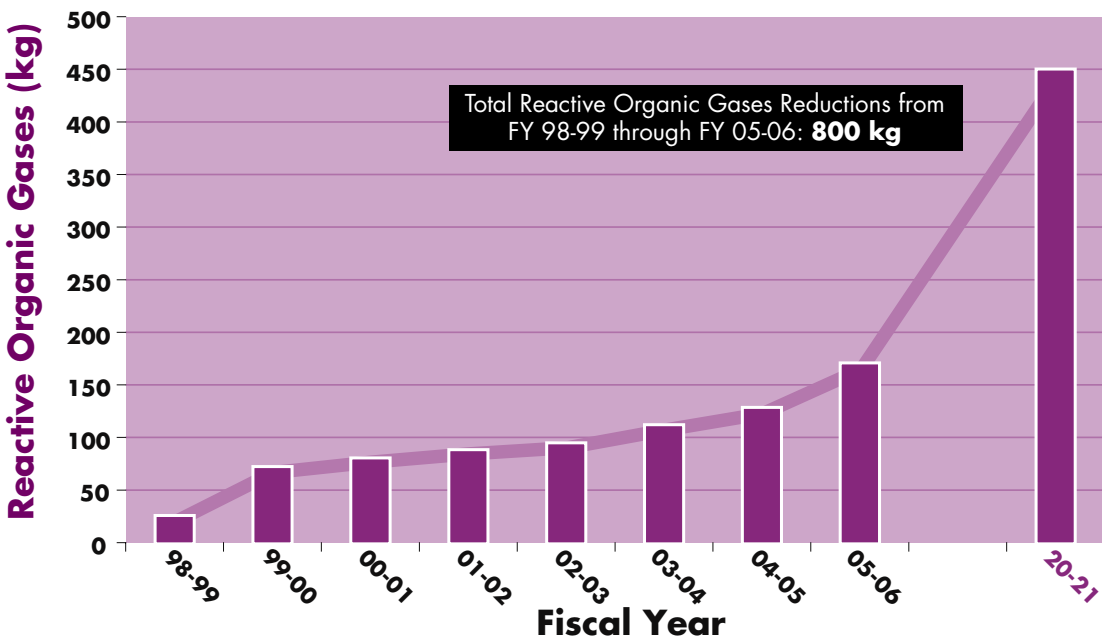


**Figure 16 • REDUCTION OF REACTIVE ORGANIC GASES BY DISTRICT WATER USE EFFICIENCY PROGRAMS (RECYCLING AND CONSERVATION)**



**Figure 16** – The District’s water use efficiency programs significantly decreased emissions of reactive organic gases over the FY 92-93 through FY 05-06 time span, with an estimated total emissions reduction of 20,900 kg (2,705 kg for FY 05-06) and a forecasted reduction for FY 20-21 of 4,485 kg.

**Figure 17 • REDUCTION OF REACTIVE ORGANIC GASES BY DISTRICT WATER RECYCLING PROGRAMS**



**Figure 17** – The District’s water recycling programs led to a reduction of 800 kg of reactive organic gases over the FY 92-93 through FY 05-06 time span, with a reduction of 170 kg for FY 05-06 and a forecasted reduction of 450 kg for FY 20-21.



Figure 18 • **REDUCTION OF REACTIVE ORGANIC GASES BY DISTRICT WATER CONSERVATION PROGRAMS**

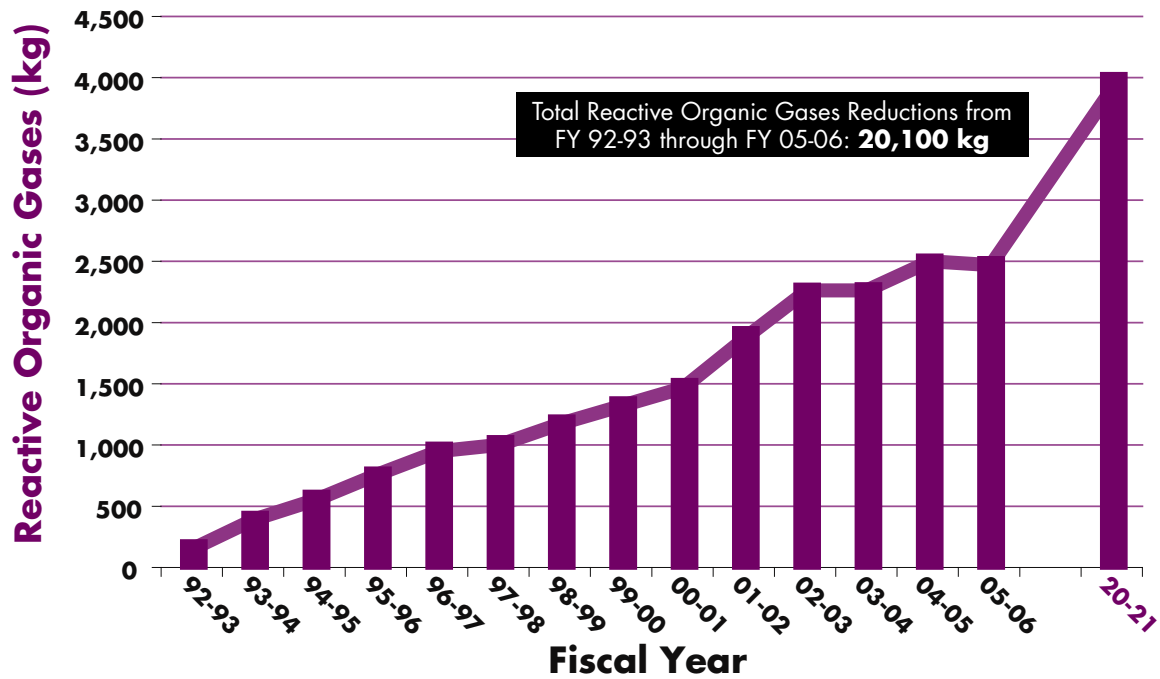


Figure 18 – The District’s water conservation programs led to a reduction of 20,100 kg of reactive organic gases over the FY 92-93 through FY 05-06 time span, with a reduction of 2,535 kg for FY 05-06 and a forecasted reduction of 4,035 kg for FY 20-21.

Figure 19 • **REDUCTION OF REACTIVE ORGANIC GASES BY DISTRICT URBAN WATER CONSERVATION PROGRAMS**

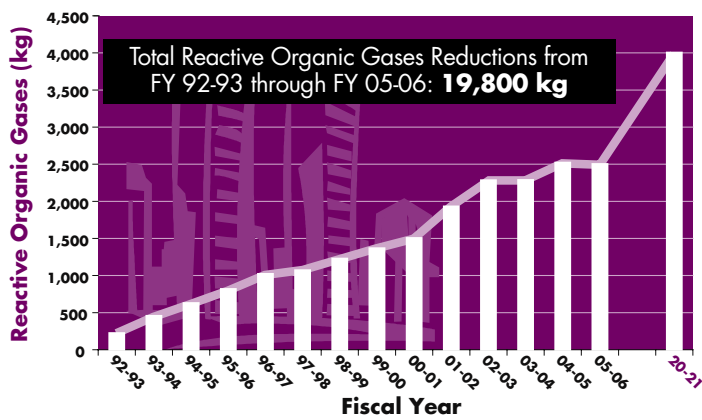


Figure 19 – The District’s urban water conservation programs led to a reduction of 19,800 kg of reactive organic gases over the FY 92-93 through FY 05-06 time span, with a reduction of 2,500 kg for FY 05-06 and a forecasted reduction of 4,000 kg for FY 20-21.

Figure 20 • **REDUCTION OF REACTIVE ORGANIC GASES BY DISTRICT AGRICULTURAL WATER CONSERVATION PROGRAMS**

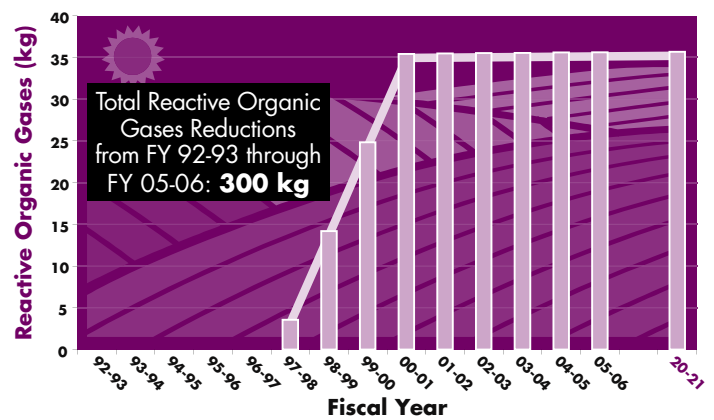
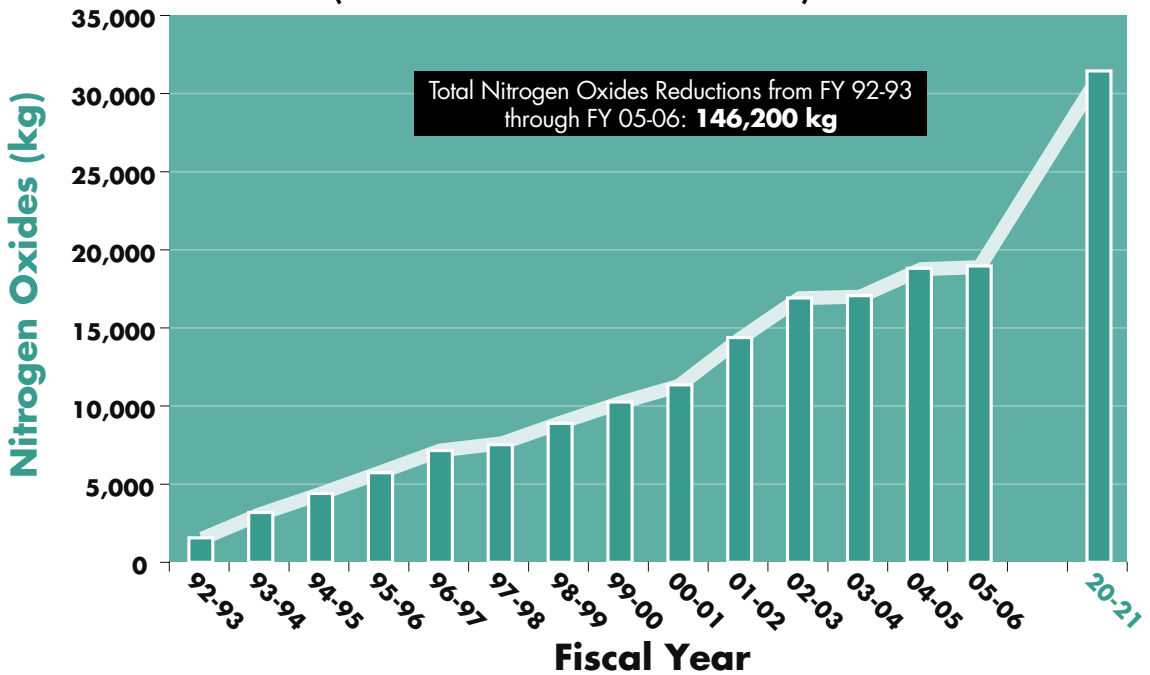


Figure 20 – The District’s agricultural water conservation programs led to a reduction of 250 kg of reactive organic gases over the FY 92-93 through FY 20-21 time span, with a reduction of 35 kg for FY 05-06 and a forecasted reduction of 35 kg for FY 20-21.

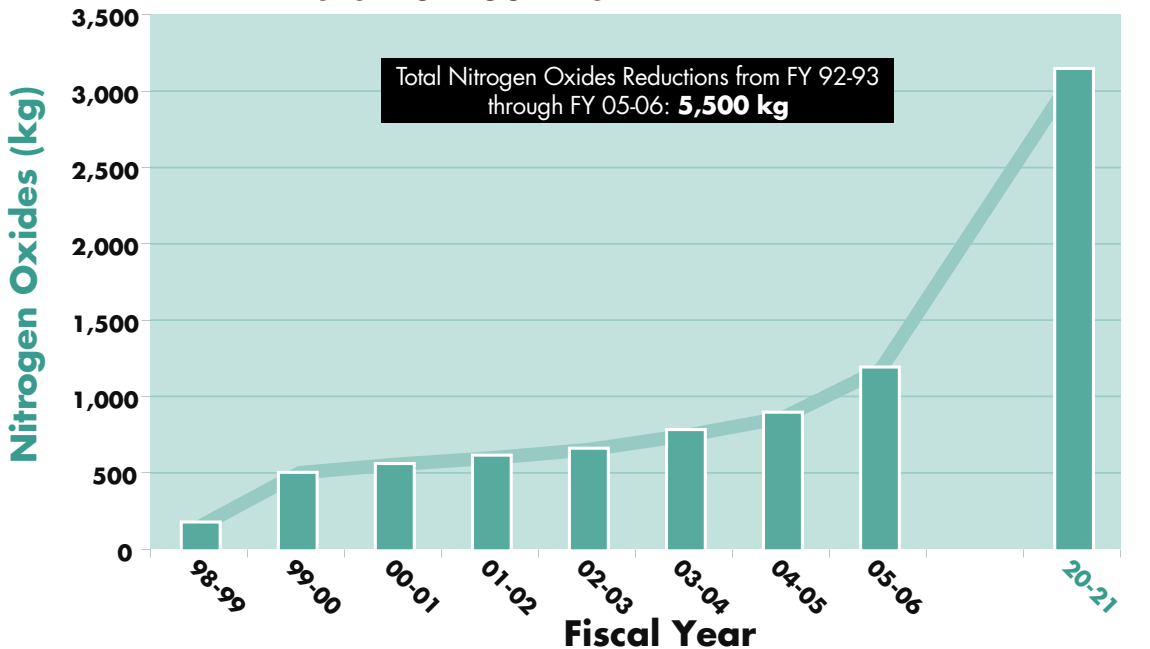


**Figure 21 • REDUCTION OF NITROGEN OXIDES BY DISTRICT WATER USE EFFICIENCY PROGRAMS (RECYCLING AND CONSERVATION)**



**Figure 21** – The District’s water use efficiency programs significantly decreased emissions of nitrogen oxides over the FY 92-93 through FY 05-06 time span, with an estimated total emissions reduction of 146,200 kg (19,000 kg for FY 05-06) and a forecasted reduction for FY 20-21 of 31,450 kg.

**Figure 22 • REDUCTION OF NITROGEN OXIDES BY DISTRICT WATER RECYCLING PROGRAMS**



**Figure 22** – The District’s water recycling programs led to a reduction of 5,500 kg of nitrogen oxides over the FY 92-93 through FY 05-06 time span, with a reduction of 1,250 kg for FY 05-06 and a forecasted reduction of 3,200 kg for FY 20-21.



Figure 23 • **REDUCTION OF NITROGEN OXIDES BY DISTRICT WATER CONSERVATION PROGRAMS**

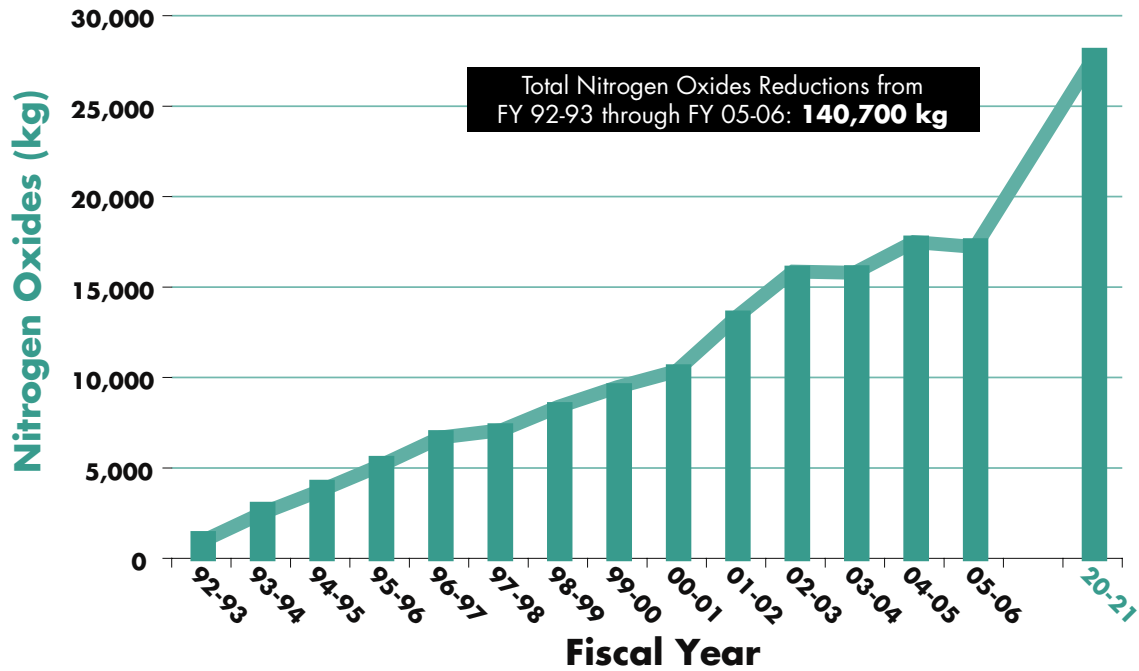


Figure 23 – The District’s water conservation programs led to a reduction of 140,700 kg of nitrogen oxides over the FY 92-93 through FY 05-06 time span, with a reduction of 17,750 kg for FY 05-06 and a forecasted reduction of 28,250 kg for FY 20-21.

Figure 24 • **REDUCTION OF NITROGEN OXIDES BY DISTRICT URBAN WATER CONSERVATION PROGRAMS**

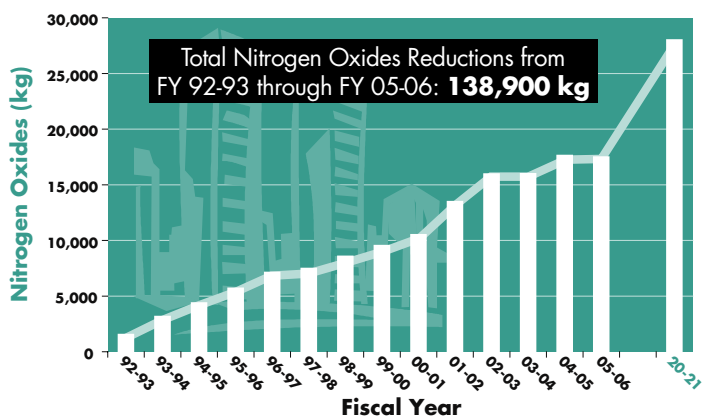


Figure 24 – The District’s urban water conservation programs led to a reduction of 138,900 kg of nitrogen oxides over the FY 92-93 through FY 05-06 time span, with a reduction of 17,500 kg for FY 05-06 and a forecasted reduction of 28,000 kg for FY 20-21.

Figure 25 • **REDUCTION OF NITROGEN OXIDES BY DISTRICT AGRICULTURAL WATER CONSERVATION PROGRAMS**

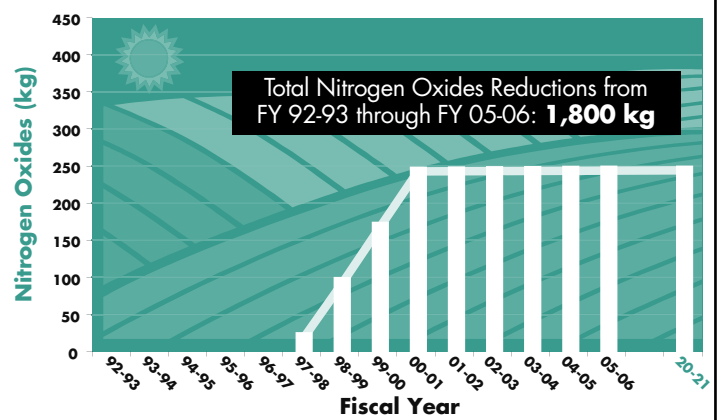
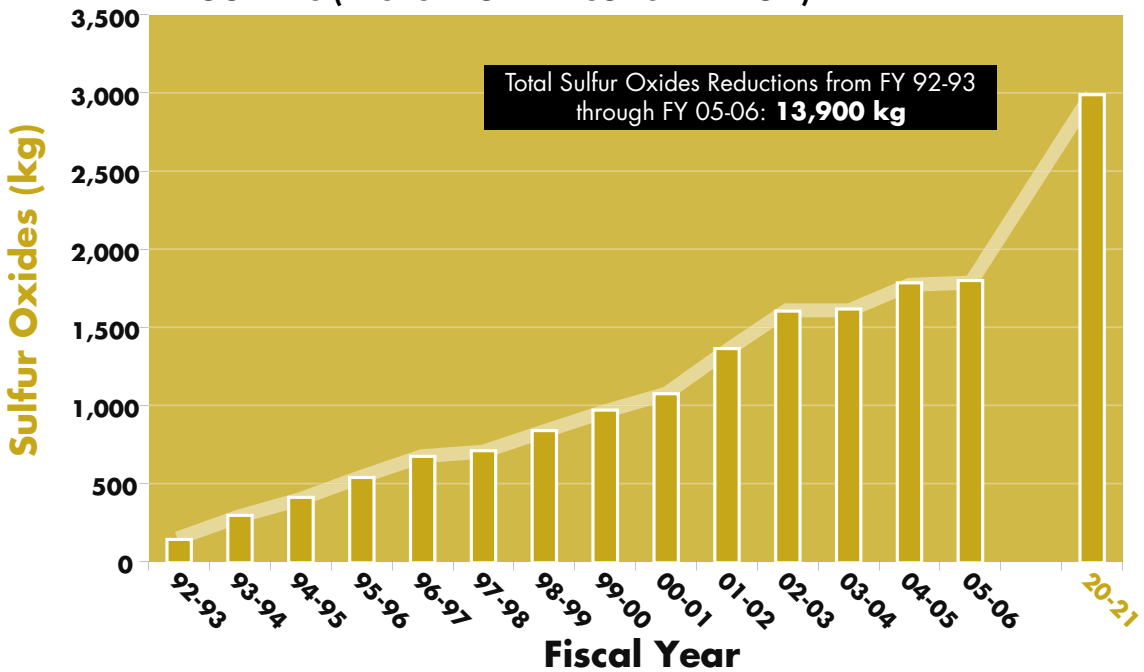


Figure 25 – The District’s agricultural water conservation programs led to a reduction of 1,800 kg of nitrogen oxides over the FY 92-93 through FY 20-21 time span, with a reduction of 250 kg for FY 05-06 and a forecasted reduction of 250 kg for FY 20-21.

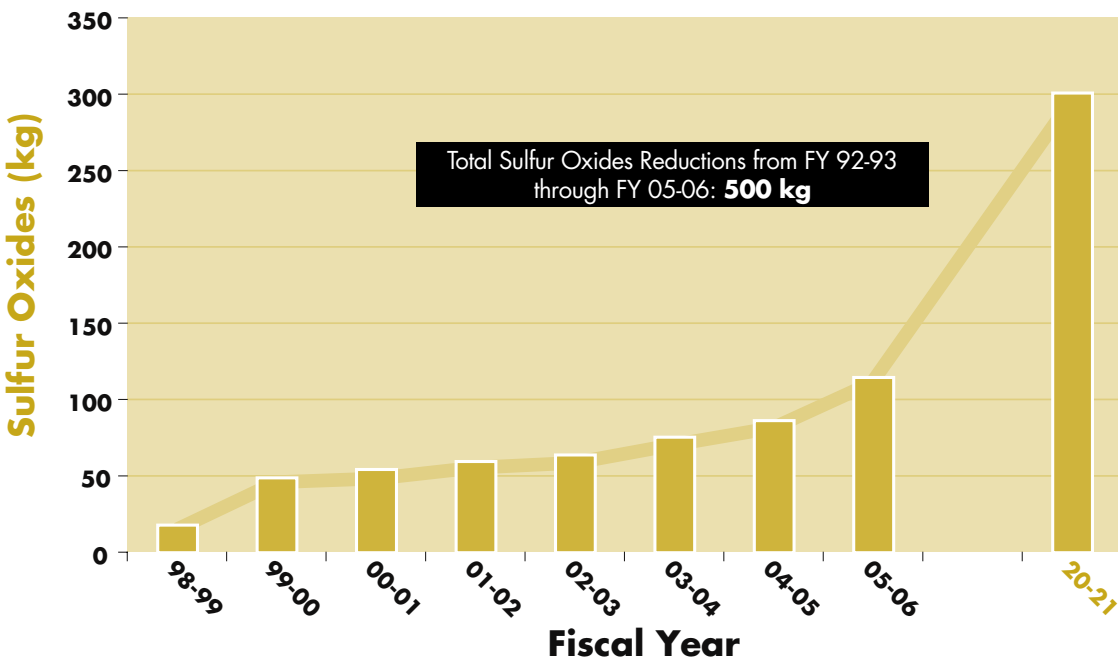


**Figure 26 • REDUCTION OF SULFUR OXIDES BY DISTRICT WATER USE EFFICIENCY PROGRAMS (RECYCLING AND CONSERVATION)**



**Figure 26 –** The District’s water use efficiency programs significantly decreased emissions of sulfur oxides over the FY 92-93 through FY 05-06 time span, with an estimated total emissions reduction of 13,900 kg (1,825 kg for FY 05-06) and a forecasted reduction for FY 20-21 of 2,925 kg.

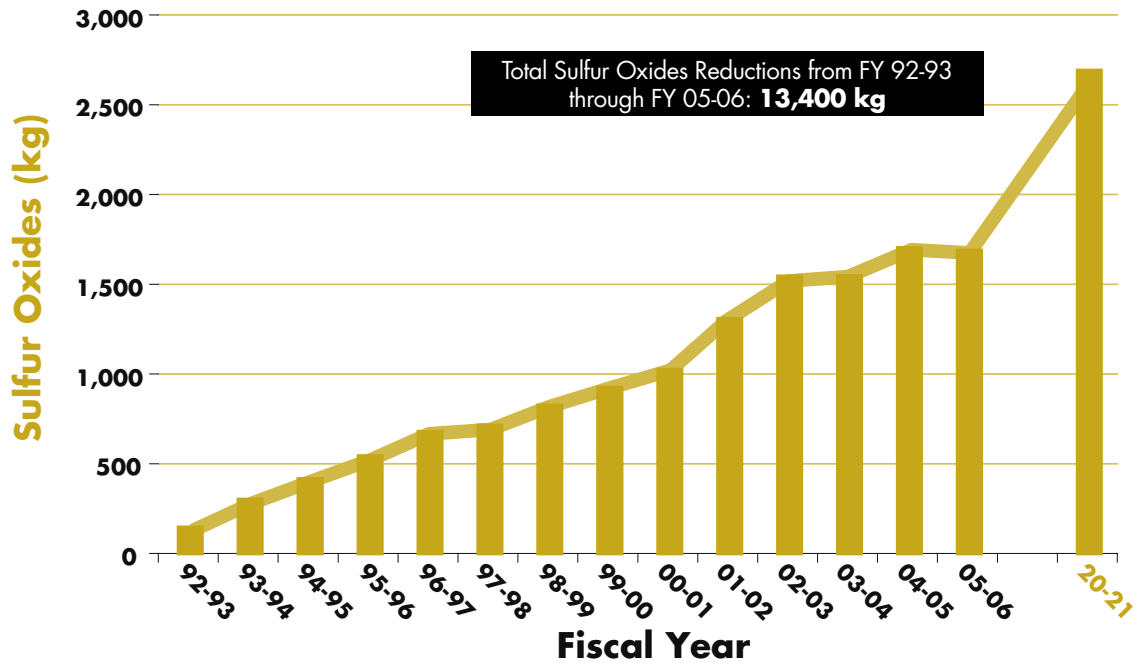
**Figure 27 • REDUCTION OF SULFUR OXIDES BY DISTRICT WATER RECYCLING PROGRAMS**



**Figure 27 –** The District’s water recycling programs led to a reduction of 500 kg of sulfur oxides over the FY 92-93 through FY 05-06 time span, with a reduction of 100 kg for FY 05-06 and a forecasted reduction of 300 kg for FY 20-21.

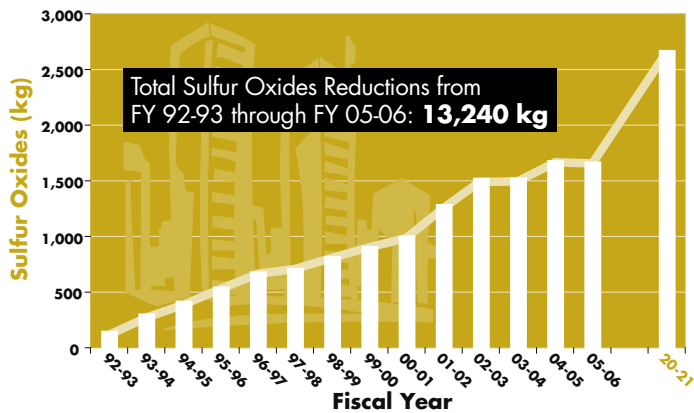


**Figure 28 • REDUCTION OF SULFUR OXIDES BY DISTRICT WATER USE CONSERVATION PROGRAMS**



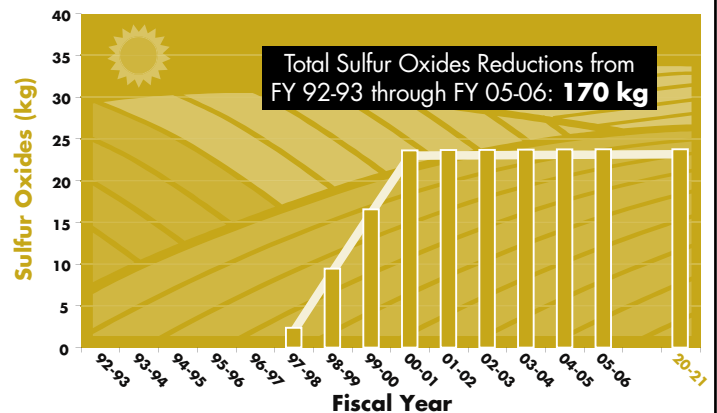
**Figure 28** – The District’s water conservation programs led to a reduction of 13,400 kg of sulfur oxides over the FY 92-93 through FY 05-06 time span, with a reduction of 1,725 kg for FY 05-06 and a forecasted reduction of 2,625 kg for FY 20-21.

**Figure 29 • REDUCTION OF SULFUR OXIDES BY DISTRICT URBAN WATER CONSERVATION PROGRAMS**



**Figure 29** – The District’s urban water conservation programs led to a reduction of 13,240 kg of sulfur oxides over the FY 92-93 through FY 05-06 time span, with a reduction of 1,700 kg for FY 05-06 and a forecasted reduction of 2,600 kg for FY 20-21.

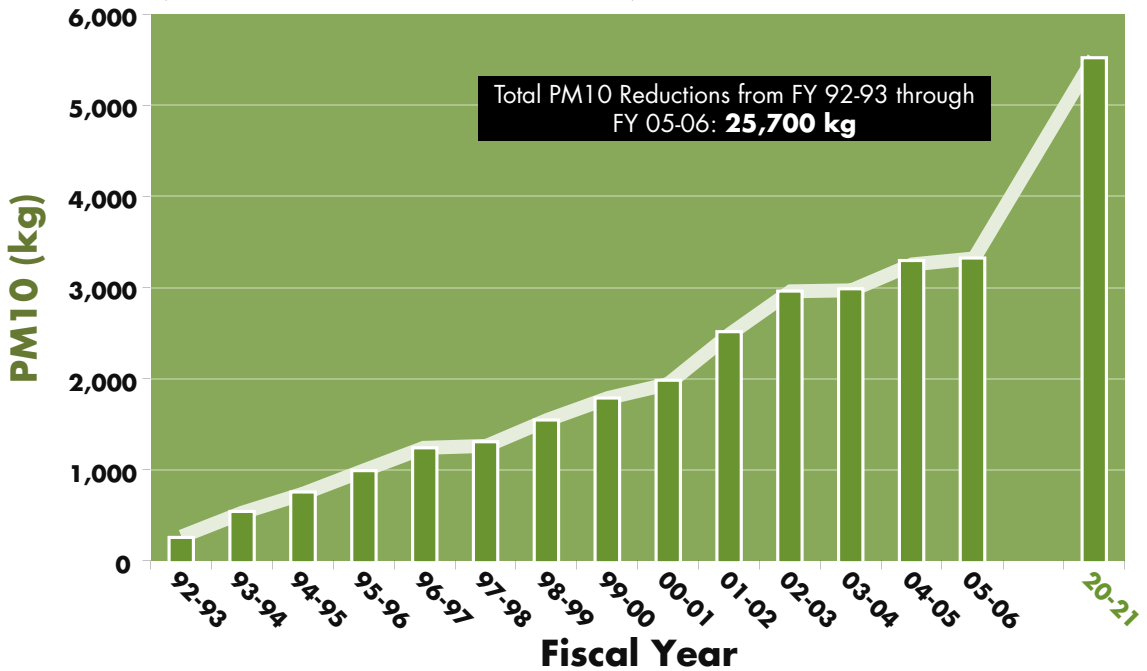
**Figure 30 • REDUCTION OF SULFUR OXIDES BY DISTRICT AGRICULTURAL WATER CONSERVATION PROGRAMS**



**Figure 30** – The District’s agricultural water conservation programs led to a reduction of 170 kg of sulfur oxides over the FY 92-93 through FY 20-21 time span, with a reduction of 25 kg for FY 05-06 and a forecasted reduction of 25 kg for FY 20-21.

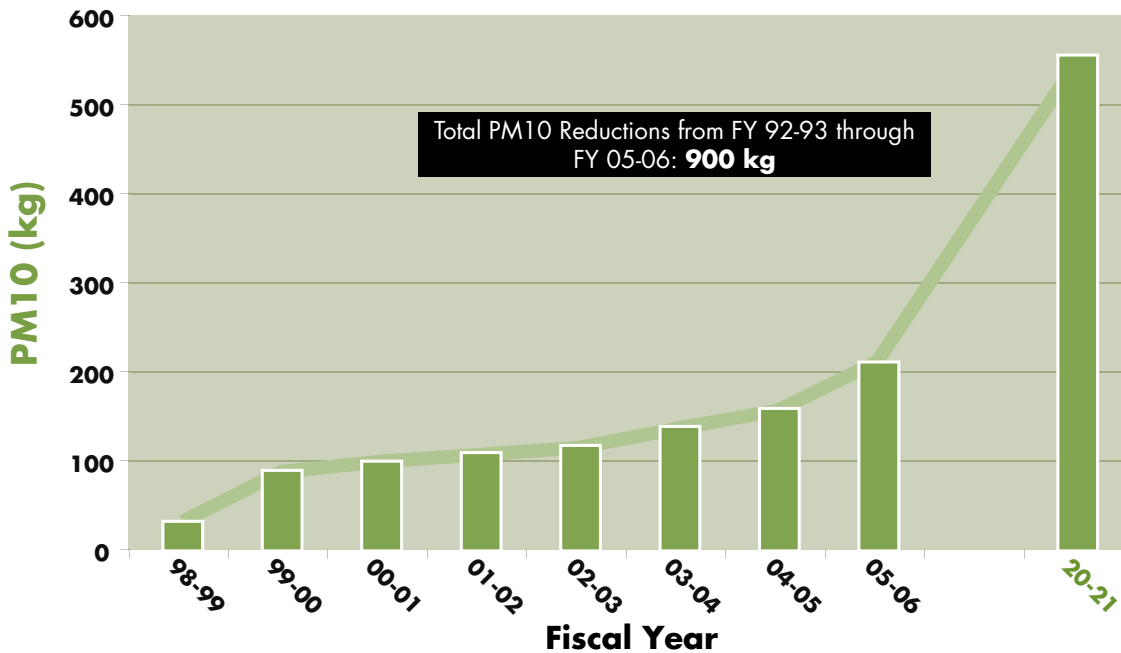


**Figure 31 • REDUCTION OF PM10 BY DISTRICT WATER USE EFFICIENCY PROGRAMS (RECYCLING AND CONSERVATION)**



**Figure 31** – The District’s water use efficiency programs significantly decreased emissions of PM10 over the FY 92-93 through FY 05-06 time span, with an estimated total emissions reduction of 25,700 kg (3,250 kg for FY 05-06) and a forecasted reduction for FY 20-21 of 5,600 kg.

**Figure 32 • REDUCTION OF PM10 BY DISTRICT WATER RECYCLING PROGRAMS**

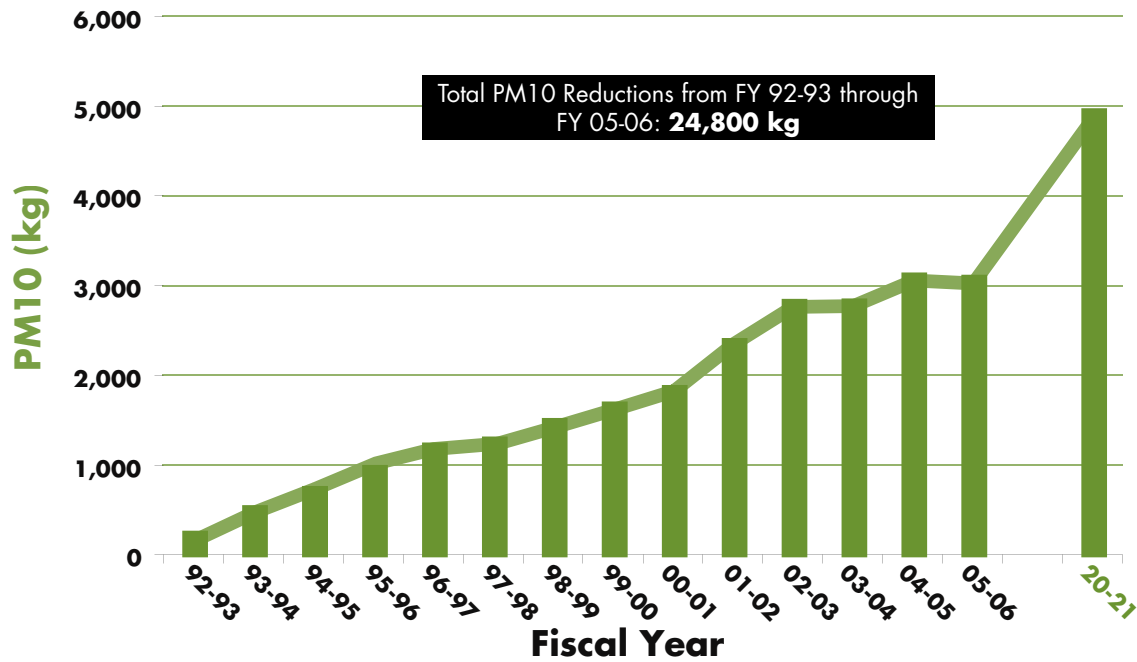


**Figure 32** – The District’s water recycling programs led to a reduction of 1000 kg of PM10 over the FY 92-93 through FY 05-06 time span, with a reduction of 200 kg for FY 05-06 and a forecasted reduction of 550 kg for FY 20-21.



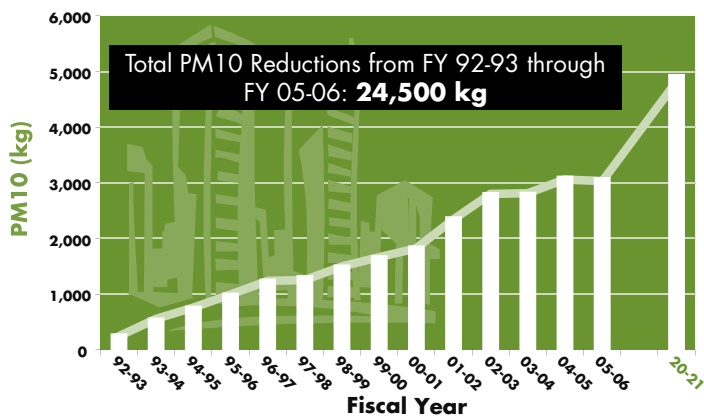


**Figure 33 • REDUCTION PM10 BY DISTRICT WATER CONSERVATION PROGRAMS**



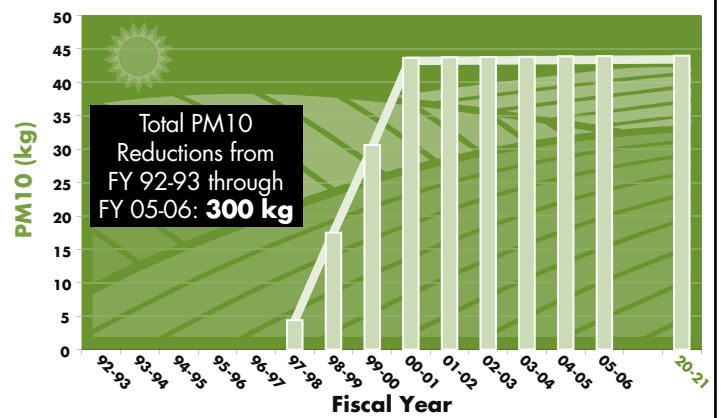
**Figure 33 –** The District’s water conservation programs led to a reduction of 24,800 kg of PM10 over the FY 92-93 through FY 05-06 time span, with a reduction of 3,050 kg for FY 05-06 and a forecasted reduction of 5,050 kg for FY 20-21.

**Figure 34 • REDUCTION OF PM10 BY DISTRICT URBAN WATER CONSERVATION PROGRAMS**



**Figure 34 –** The District’s urban water conservation programs led to a reduction of 24,500 kg of PM10 over the FY 92-93 through FY 05-06 time span, with a reduction of 3,000 kg for FY 05-06 and a forecasted reduction of 5,000 kg for FY 20-21.

**Figure 35 • REDUCTION OF PM10 BY DISTRICT AGRICULTURAL WATER CONSERVATION PROGRAMS**



**Figure 35 –** The District’s agricultural water conservation programs led to a reduction of 300 kg of PM10 over the FY 92-93 through FY 05-06 time span, with a reduction of 50 kg for FY 05-06 and a forecasted reduction of 50 kg for FY 20-21.



## Breakdown of Energy Savings from Water Conservation

As shown in Figures 5 through 35, when compared to water recycling or agricultural water conservation, the District's urban water conservation programs have resulted in the greatest energy savings and air quality benefits; this is primarily because of the significant end use energy savings (and air quality benefits) that accrue due to reduced demand for hot water. With respect to the District's urban water conservation programs, 97% of the end use energy savings are due to residential hot water conservation programs while 3% of the end use energy savings are due to CII hot water conservation programs. The greater contribution of residential hot water conservation programs to urban end use energy savings is due to their earlier inception (and to plumbing code changes); the low-flow showerhead distribution program began in FY 92-93 and both the faucet aerator distribution program and the residential high-efficiency clothes washer rebate program began in FY 95-96 while the CII high-efficiency clothes washer rebate program began in FY 00-01 and the pre-rinse sprayer direct installation program began in FY 02-03. Figures 36 through 39 show the energy savings and carbon dioxide emissions reductions brought about by selected residential and CII water conservation programs. The residential showerhead program has resulted in the greatest energy savings (and carbon dioxide emissions reductions; Figures 36-37).



*The District distributes low-flow showerheads and faucet aerators at community outreach events.*



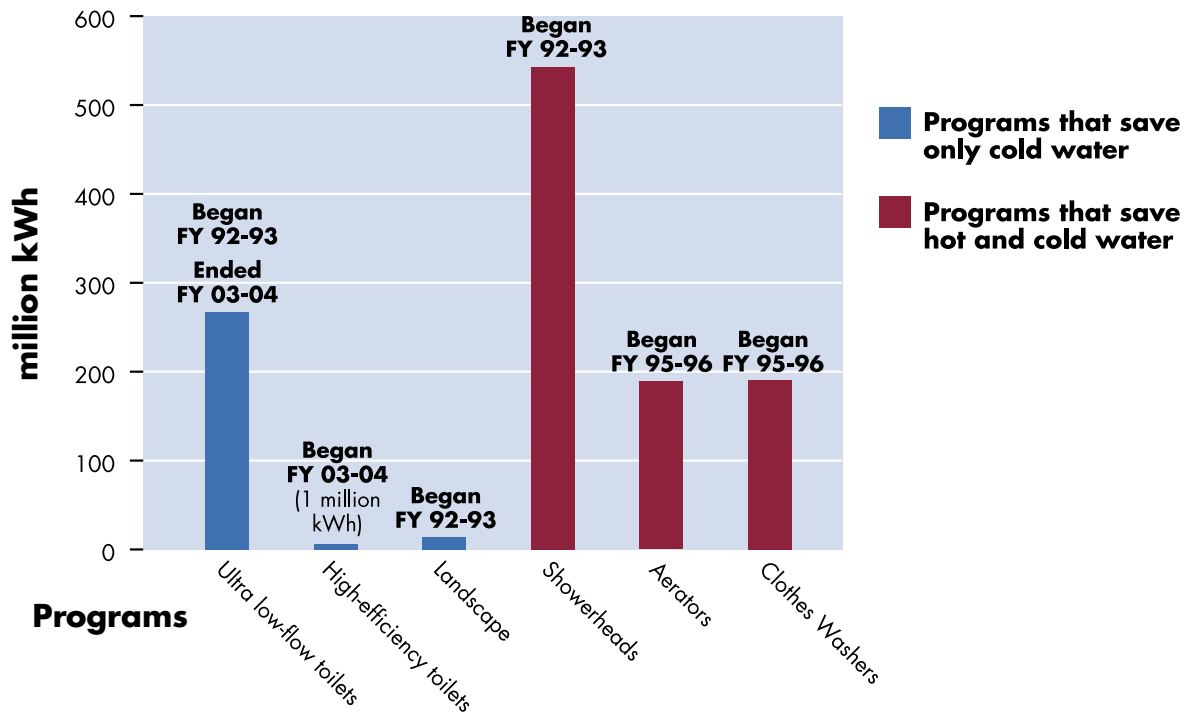
*High-efficiency pre-rinse sprayers save water and energy.*

The CII and residential ultra low flush toilet programs have also resulted in significant energy savings (and carbon dioxide emissions reductions) as has the CII pre-rinse sprayer program (Figures 36-39).

Because of these data (Figures 36-39) and because the residential sector uses a greater proportion of urban water supplies than the CII sector (District averages are 60% and 40% respectively), it may appear that end use energy savings potential is greater in the residential sector than in the CII sector.<sup>42</sup> However, the majority of residential water use is for landscape irrigation (50%-70%, depending on location and time of year), which does not use hot water at the end use step (nor significant quantities of energy for pumping, cooling, or purifying water) while the majority of CII water use at the end use step is for heating, cooling, pumping, or filtering water.<sup>43</sup> **Thus, significant end use energy savings potential still exists in the CII sector.**



**Figure 36 • ENERGY SAVINGS FROM SEVERAL DISTRICT RESIDENTIAL WATER CONSERVATION PROGRAMS**



**Figure 37 • REDUCTION OF CARBON DIOXIDE BY SEVERAL DISTRICT RESIDENTIAL WATER CONSERVATION PROGRAMS**

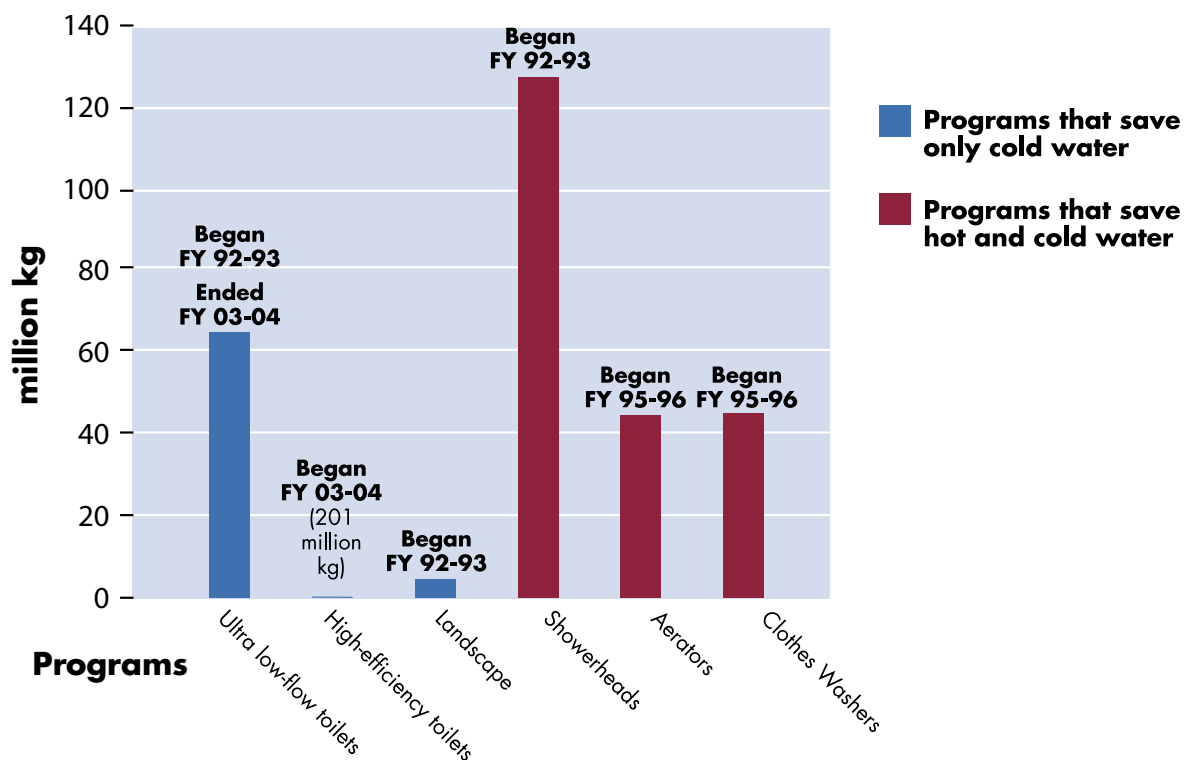




Figure 38 • ENERGY SAVINGS FROM SEVERAL DISTRICT CII WATER CONSERVATION PROGRAMS

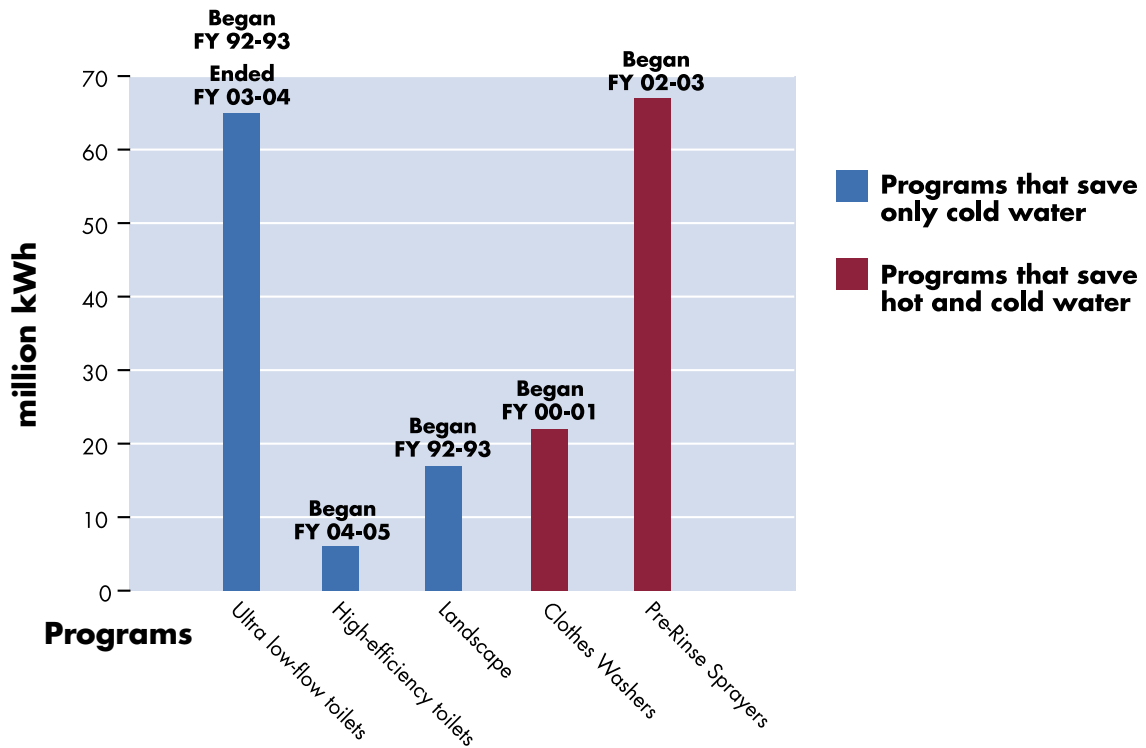
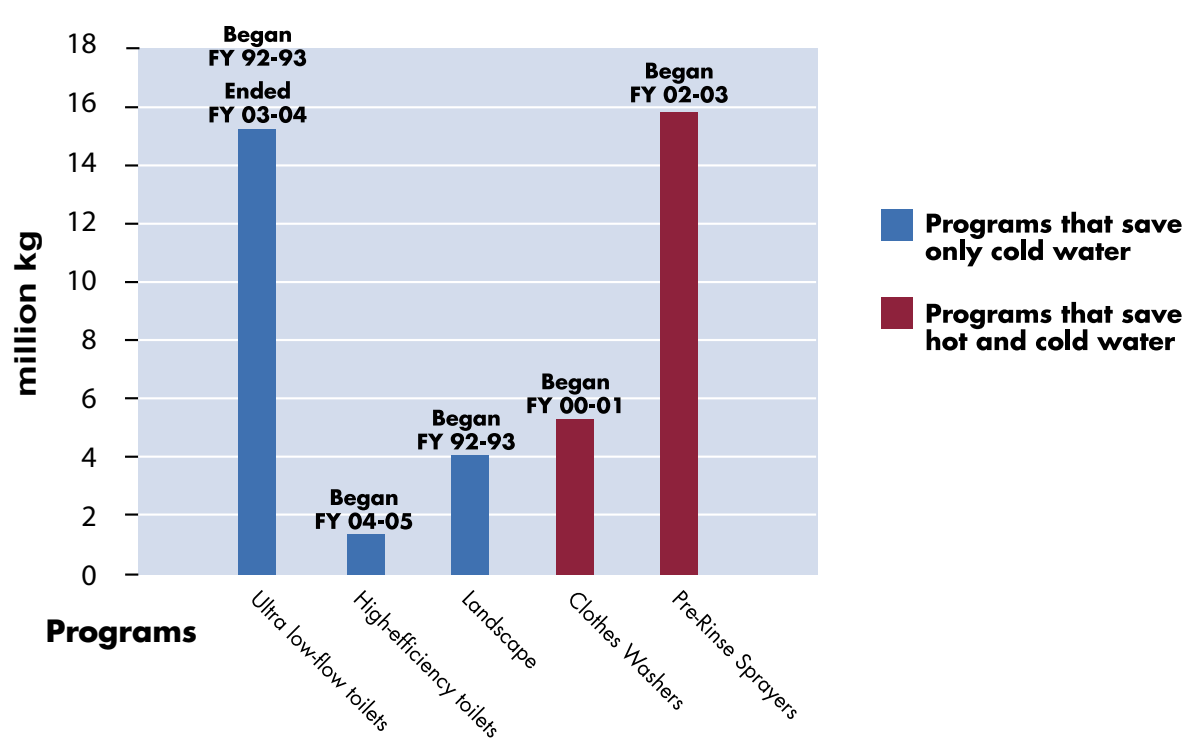


Figure 39 • REDUCTION OF CARBON DIOXIDE BY SEVERAL DISTRICT CII WATER CONSERVATION PROGRAMS





## Potential End Use Energy Savings from Hot Water Conservation

As mentioned previously, significant energy savings (and air pollutant emissions reductions) opportunities are still present in the CII and residential sectors for hot water conservation. For example, the District recently completed a residential baseline study to estimate current saturation rates of water-efficient devices in single-family and multiple-family dwellings as well as to estimate future water savings potential.<sup>44</sup> The baseline study estimated that there are approximately 288,500 high-flow showerheads remaining in Santa Clara County; **if all of these showerheads were replaced with low-flow showerheads, the lifetime water savings would be approximately 8,800 AF while the lifetime energy savings would be approximately, 1.26 billion kWh.**<sup>45</sup> Similarly, the baseline study estimated that there are approximately 307,900 water-inefficient clothes washers remaining in Santa Clara County; **their replacement with high-efficiency clothes washers would lead to a lifetime water savings of approximately 72,500 AF and a lifetime energy savings of approximately 2.84 billion kWh.**<sup>46</sup>

As another example, the Water Efficient Technologies program offers rebates for devices that save energy and water (in the CII sector) such as connectionless steamers, which are used for cooking by the food service industry. Connectionless steamers save approximately 224,400 gallons of water per year



*Low-flow showerheads save water and energy.*



*The District offers a comprehensive suite of water use efficiency programs for both homes and businesses.*

and approximately 19,000 kWh of electricity per year.<sup>47</sup> There are an estimated 2,974 restaurants, hospitals, and other commercial kitchens in the county that are eligible for replacement with a connectionless steamer, leading to a lifetime water savings of 20,000 AF and a lifetime energy savings of 604 million kWh.<sup>48</sup>

**The District will continue to offer its successful urban water conservation programs as well as focus on the development of new urban water conservation programs that offer water-saving as well as energy-saving potential.**



### Energy Consumption for End Uses

While the heating of water is the major end use energy demand in the urban sector, energy is also consumed for other end uses such as cooling water, pumping water, and purifying water, particularly in the CII sector. Water-related energy use data on the latter three processes for the CII sector are limited as they are generally embedded into broader categories and/or are organized according to type of production or process (e.g., energy required for a manufacturing plant to produce one unit).<sup>49</sup> A better understanding of water-related end use energy demand in the CII sector will prove useful for designing effective urban water conservation programs.

### Sources of Uncertainty

While the model estimates energy savings and air emissions reductions under particular scenarios, it is important to note that these numbers are only estimates due to the uncertainty that exists for as well as the variability associated with many of the model inputs (e.g., air emissions from a particular energy source). To gain a sense of the range for each model input and output such as energy savings, confidence intervals should be determined. However, this approach is beyond the scope of the project and is currently infeasible due to limitations in the data. Thus, the model estimates of energy savings and air emissions reductions as presented in this analysis were derived using the best (but not the only) inputs for each scenario.<sup>50</sup>



*Connectionless steamers save water and energy.*



## The Santa Clara Valley Water District: Saving Water, Saving Energy, and Reducing Air Pollution

In addition to saving energy and reducing air emissions through its water conservation and water recycling programs, the District engages in other practices and activities that save energy and reduce air emissions. For example, in 2004 the District received its Green Business Certification as a result of its commitment to water-efficient and energy-efficient practices and procedures as well as to pollution prevention and solid waste reduction.

As part of this “green” effort, the District completed a \$3 million state-of-the-art solar energy project at the District’s headquarters campus, installing photovoltaic solar panels on the District’s administration building’s roof and on the roof of two carports in the parking lot (Figure 40). **For FY 04-05, the solar panel arrays produced 544,800 kWh of electricity, providing approximately 20% of the headquarters campus’s energy demands and saving approximately \$240,000 in annual energy costs.** During FY 04-05 the solar panel arrays



*The District uses hybrid vehicles to reduce its carbon footprint.*

also provided emissions reductions of approximately 893,500 pounds of carbon dioxide, 20 pounds of nitrogen oxides, and 200 pounds of sulfur oxides.

An additional source of power generation comes from the District’s Anderson Dam Hydroelectric generation facility, located in the southern part of the county. **The Anderson Dam Hydroelectric facility has generated over 27,500,000 kWh of electricity since its construction in 1988, generating 713,000 kWh of non fossil fuel-based electricity during FY 05-06 alone.** The electricity generated from Anderson Hydroelectric facility is sold back to PG&E.

The District is also a member of Sustainable Silicon Valley (SSV), “a partnership between businesses, governments, academia, and non-governmental organizations that seeks cooperative solutions to the environmental challenges facing the greater Silicon Valley region.”<sup>51</sup> As part of this work with SSV, the District is committed to reducing its carbon dioxide emissions through its programs and practices, including the replacement of its oldest fleet vehicles with hybrid vehicles.

**Bay Area Green Business Program**

**GREEN BUSINESS PLEDGE**

“We believe a successful business is dependent upon a healthy environment. We are actively working to show our environmental responsibility to our community by committing to the following objectives

- To comply with all applicable environmental regulations and strive to exceed compliance
- To conserve energy, water and other natural resources
- To develop and implement practices that prevent pollution and waste
- To be an environmentally responsible business within our community.”

**Santa Clara Valley  
Water District**



*Adopted by Santa Clara Valley Water District  
March 4, 2003*

*The District’s Green Business Pledge.*



*Figure 40* • **The District's Solar Panel Arrays**







## Findings and Recommendations

---

The District will continue to improve the energy efficiency and water use efficiency of its operations, buildings, and practices because of its strong commitment to the efficient use of these two valuable resources.

The District has shown the significant energy savings and air emissions reductions achieved by the District's projects and programs, particularly by urban water conservation, in this report. The District Board's Ends Policies and the District's Urban Water Management Plan both emphasize the importance of water conservation and water recycling for meeting future water supply goals. **In the future, the District will continue to expand its successful water conservation and water recycling programs through the following activities:**

- **Integrate energy savings and air quality benefits into cost-benefit analyses.**

The results of these analyses will be factored into programmatic decisions to maximize multiple benefits.

- **Expand cost-sharing partnerships with the District's retailers.**

Cost-sharing on programs makes the most efficient use of limited resources.

- **Expand regional programs co-offered with other Bay Area water agencies.**

Offering regional programs is more cost-effective and leads to shared knowledge, thus providing financial and intellectual leverage.

- **Seek increased grant funding.**

Grant funding provides funds for additional programs, some of which may not be locally cost-effective (but are regionally cost-effective). In the future, additional sources of funding may be available through the energy sector.

- **Develop Water Agency-Energy Utility partnerships.**

The District has recently begun discussions with local energy utilities regarding a partnership

to develop programs that save both water and energy.

At the research level, the District supports further investigation and quantification of the water-energy-air emissions connection. For example, more research is needed regarding water-related end use energy use in the CII sector as well as regarding the energy used for distribution and advanced treatment of recycled water.

At the state policy level, the District supports the integration of energy policies with water policies. This is because increased coordination among state resource management agencies (i.e., California Department of Water Resources, California Energy Commission, California Public Utilities Commission) will lead to more effective water and energy policies. Toward this end, the District recommends that the California Department of Water Resources should incorporate an energy intensity analysis and recommend strategies for reducing water-related energy use into the next California Water Plan. Additionally, the District recommends that the California Urban Water Conservation Council incorporate energy costs and benefits into its standard cost-benefit methodology and encourage water agencies to consider energy implications of water conservation programs.

**The District also supported the passage of AB 32, the Global Warming Solutions Act, which requires California to cut its greenhouse gas emissions by about 25 percent by 2020.**

Finally, the District recommends increased financial support from energy utilities as well as state agencies for water use efficiency, particularly cold water conservation, because of the significant energy savings, air quality benefits, and role in global climate change mitigation.

### Water Supply

Staff obtained historical water supply values for FY 92-93 through FY 05-06 from the District's Water Utility Enterprise Reports and from the District's Urban Water Management Plan reports. Water supply projections for FY 20-21 were obtained from the District's Board's Ends Policies and the District's Integrated Water Resources Planning Study 2003. Water conservation, water recycling, imported water, groundwater, and surface water were the five water supply sources considered for this analysis; desalination was not considered because it is not currently a water supply source (though may be one in the future). Water supply values were entered into the Water to Air Model to analyze the difference between two water supply scenarios (this was done for each fiscal year from FY 92-93 through FY 05-06 and for FY 20-21). Scenario 1 assumed the presence of water conservation (or water recycling, depending on which water supply option was being analyzed) while scenario 2 assumed the absence of water conservation (or water recycling, depending on which water supply option was being analyzed). For scenario 2, it was assumed that water neither conserved nor recycled was supplied by imported water because local groundwater and surface water supplies are limited and imported water represents the next lowest cost supply source. A sample input sheet and output sheet of the model are shown in Figures 41 and 42.

As water flows through the water supply chain, a water loss of 5% during conveyance, 7% during treatment, and 7% during distribution was assumed; water losses occur due to evaporation, seepage, and system leakage. For example, the California State Water Project and the Federal Central Valley Project both estimate conveyance losses of 5%.<sup>52</sup> Consumptive use of water (for irrigation, drinking, etc) during the end use step was assumed to be 54%, a default value used in the Water to Air model (based on case studies of urban areas in California) but one that appears consistent with water use patterns in the District's service area.<sup>53</sup> Thus, 46% of the water from the end use step enters wastewater treatment plants and becomes treated wastewater.

### Energy Sources and Factors

An energy source (e.g., natural gas, hydropower, coal) was specified for each energy-consuming step in the water supply chain. The California electricity grid, which represents average electricity purchased by (or produced from) the average electric utility in California from a mix of energy sources (coal, natural gas, hydropower, etc.), was assumed to be the energy source for each energy-consuming step in the water supply chain; however, the air emissions factors for the California grid were adjusted to reflect the air emissions factors for the mix of energy sources owned (or purchased) by Pacific Gas and Electric (PG&E), the utility provider for much of Northern California and the Bay Area (PG&E was assumed to be the energy provider for all steps in the water supply chain).<sup>54</sup>

For calendar year 2004, the most recent year for which data are available, the mix of PG&E energy sources used to generate electricity were as follows: 55% renewable (19% large hydropower, 24% nuclear, 1.4% wind, 3.9% small hydropower, 2.6% solar, 2.5% geothermal, and 1.6% biomass), 43% natural gas, and 1.7% coal (see further discussion of this below under the air emissions reductions section).<sup>55</sup> Total energy, electrical energy plus thermal energy (the source of energy for some end use devices), converted into kWh is reported in the model outputs as equivalent energy (or kWh) and is the parameter used throughout this report (but is simply referred to as "energy" or "energy savings"). Electricity costs represent average 2005 PG&E rates for businesses and residences located in Northern California (\$.13/kWh).<sup>56</sup>

With respect to the energy source assumptions for imported water, it should be noted that a significant portion of the energy required for conveyance of water through the State Water Project (SWP) or the Central Valley Project (CVP) comes from the projects' hydroelectric power plants located in Northern California (e.g., Lake Oroville-Hyatt Thermalito Complex) and at hydroelectric generators located at pumping stations along the



projects' length (e.g., Devil's Canyon pumping station of the SWP, located in Southern California). For example, for FY 05-06 approximately 45% of the energy required for the operation of the SWP was obtained from SWP hydroelectric power, with the remainder coming from a partially SWP-owned coal fired power plant in Nevada and from the California electric grid. While hydroelectric power does not have air pollutant emissions associated with it as does fossil fuel-based energy sources, an assumption was made that hydroelectric power saved through the District's water conservation and water recycling programs can be used to offset fossil fuel-based energy use elsewhere and thus the District has chosen to take credit for the air pollutant emissions (using the air emissions factors for the PG&E grid as mentioned earlier). A corollary of this assumption is that it is also assumed that SWP and CVP operations, including hydroelectric power generation, did not and will not change in response to the District's water conservation and water recycling savings; that is, it is assumed that hydroelectric

energy saved through the District's water conservation and water recycling programs is still available for use by the projects or for sale to the California electric grid. Finally, the terms "energy savings" and "air pollutant emissions reductions" refer to benefits that accrue to the District.

Prior to the estimation of the energy savings due to water conservation and water recycling, energy factors were calculated for each step of the water supply chain. Energy factors are the ratio of energy consumed (kWh/yr) to water consumed (AF/yr) and allow for comparisons of energy use on a per water unit basis (kWh/AF). The model uses energy factors as a multiplier for water supply values to determine energy embedded in each step of the water supply chain. Where possible, District-specific energy factors were used; Table 2 lists energy factors used for this analysis and their source.



*The District's solar panel arrays provide electricity for the headquarters campus.*



Table 2 • ENERGY FACTORS

Energy-Consuming Step	Energy Factor (kWh/AF)
Source and Conveyance (0-4,600 kWh/AF) <sup>a</sup>	
Groundwater	650 <sup>b</sup>
Surface Water	0 <sup>c</sup>
Recycled Water	900 <sup>d</sup>
Imported Water	1000 <sup>e</sup>
Water Treatment (33-5,200 kWh/AF) <sup>a</sup>	100 <sup>f</sup>
Water Distribution (330-26,000 kWh/AF) <sup>a</sup>	320 <sup>g</sup>
Wastewater Treatment (360-1,500 kWh/AF) <sup>a</sup>	440 <sup>h</sup>

<sup>a</sup> Numbers in parentheses are ranges for California water agencies and are from CEC (2005).

<sup>b</sup> From groundwater pumping operations data for several in-county groundwater well fields.

<sup>c</sup> Default value for model; assumes gravity-fed system.

<sup>d</sup> Calculated based on data from and personal communication with staff of South Bay Water Recycling (SBWR) at the San Jose/Santa Clara Water Pollution Control Plant; the energy factor reflects the pumping energy required for the recycled water distribution system but does not include tertiary treatment (as this is required prior to discharge into San Francisco Bay and is not an incremental cost associated with recycled water production). SBWR has the largest distribution system of the four recycled water production plants in the county so this energy factor likely represents the high end of the range.

<sup>e</sup> From Wilkinson (2000). The energy factor represents pumping costs to the South Bay Aqueduct delivery point for the California State Water Project. This energy factor is derived from 1996–1997 data; it should be noted that energy factors will vary from year to year depending on

project deliveries. These values do not account for hydro-power generation by the SWP or the CVP because energy production by these projects occurs independently of energy consumption.

<sup>f</sup> Calculated based on data from and personal communication with District staff. Total energy consumption by each of the District’s three water treatment plants was divided by volume of water treated by each plant; the energy factor is an average of the energy factors for the three treatment plants. Assumes energy consumption by the treatment plants for non-treatment related purposes (lighting, etc.) is negligible.

<sup>g</sup> Calculated based on data from and personal communication with District staff. Total energy consumption of the District’s in-county pumping system divided by volume of water conveyed with 30% added to reflect retailers’ pumping energy costs for distribution.

<sup>h</sup> From CEC (2005). Represents average for wastewater treatment plants in Northern California. Assumes all energy consumption is volume-dependent.



Figure 41 • SAMPLE INPUT SPREADSHEET



# Water to Air Model

## Urban Management Version

Portfolio of Energy Mix									
	California Grid Mix	Natural Gas Power Plant	Oil Fired Power Plant	Natural Gas Direct Drive	Coal Fired Power Plant	Hydro/Solar/Wind/Nuclear	Diesel Direct Drive	Biogas Generation	Biogas Direct Drive
Mix 1	100%	0%	0%	0%	0%	0%	0%	0%	0%
Mix 2	0%	100%	0%	0%	0%	0%	0%	0%	0%
Mix 3	0%	0%	100%	0%	0%	0%	0%	0%	0%
Mix 4	0%	0%	0%	100%	0%	0%	0%	0%	0%
Mix 5	0%	0%	0%	0%	100%	0%	0%	0%	0%
Mix 6	0%	0%	0%	0%	0%	100%	0%	0%	0%
Mix 7	0%	0%	0%	0%	0%	100%	0%	0%	0%
Mix 8	0%	0%	0%	0%	0%	0%	0%	100%	0%

	Input > 1 Facility?	See Facility List	AF per Year	Use Default Values?	Default Energy Use (Kwh/Yr)	Actual Energy Use (Kwh/Yr)	Portfolio of Energy Mix
<b>Sources &amp; Conveyance</b>							
Groundwater	<input type="checkbox"/> Yes			yes			Mix 1
Local Surface Water	<input type="checkbox"/> Yes			yes			Mix 1
Reclamation	<input type="checkbox"/> Yes			yes			Mix 1
Imported	<input type="checkbox"/> Yes			yes			Mix 1
Desalination	<input type="checkbox"/> Yes			yes			Mix 1
<b>Water Treatment</b>	<input type="checkbox"/> Yes			yes			Mix 1
<b>Water Distribution</b>	<input type="checkbox"/> Yes			yes			Mix 1
<b>Customer Use</b>	<input type="checkbox"/> Yes			yes			Mix 1
<b>Waste Water Collection</b>	<input type="checkbox"/> Yes			yes			Mix 1
<b>Waste Water Treatment</b>	<input type="checkbox"/> Yes			yes			Mix 1

<b>Select Scenario</b>	<b>Scenario 2</b>	<b>Update Scenario</b>
------------------------	-------------------	------------------------

CALCULATOR - MGD to AF/YR to MGD			
Input		Output	
0	MGD	-	AF/YR

CALCULATOR - Liquid Energy to Equivalent kwh					
Input			Output		
Fuel Type	Natural Gas	0	100 cubic ft	-	equivalent kwh



Figure 42 • SAMPLE OUTPUT SPREADSHEET



# Water to Air Model

## Urban Management Version

Scenario 1	Reactive Organic Gases	Carbon Monoxide	Nitrogen Oxides	Sulfur Oxides	Particulates <10 Microns	Carbon Dioxide	Energy Use (equivalent Kwh/YR)	California Grid Mix
<b>Sources &amp; Conveyance</b>	4,442,422	63,963,8335	31,106,011	2,963,627	5,480,597	142,145,445,000	301,795,000	
Groundwater	1,572,022	22,539,085	11,007,361	1,048,727	1,939,397	50,300,445,000	106,795,000	100%
Surface Water	-	-	-	-	-	-	-	100%
Reclamation	-	-	-	-	-	-	-	100%
Imported	2,870,4000	41,154,750	20,098,650	1,914,900	3,541,200	91,845,000,000	195,000,000	100%
Desalination	-	-	-	-	-	-	-	100%
<b>Water Treatment</b>	567,611	8,138,194	3,974,431	378,664	700,259	18,161,995,500	38,560,500	100%
<b>Water Distribution</b>	1,689,206	24,219,220	11,827,884	1,126,902	2,083,966	54,050,000,640	114,755,840	100%
<b>Customer Use</b>	-	-	-	-	-	-	-	100%
<b>Waste Water Collection</b>	-	-	-	-	-	-	-	100%
<b>Waste Water Treatment</b>	5,646,635	80,945,062	39,530,952	3,766,314	6,964,996	180,644,985,000	383,535,000	100%
<b>Total</b>	12,344,874	176,996,310	86,439,278	8,235,507	15,229,818	395,002,426,140	838,646,340	

Scenario 2	Reactive Organic Gases	Carbon Monoxide	Nitrogen Oxides	Sulfur Oxides	Particulates <10 Microns	Carbon Dioxide	Energy Use (equivalent Kwh/YR)	California Grid Mix
<b>Sources &amp; Conveyance</b>	5,107,295	73,226,541	35,761,476	3,407,177	6,300,848	163,419,573,000	346,963,000	
Groundwater	1,572,022	22,539,085	11,007,361	1,048,727	1,939,397	50,300,445,000	106,795,000	100%
Surface Water	-	-	-	-	-	-	-	100%
Reclamation	-	-	-	-	-	-	-	100%
Imported	3,535,273	50,687,456	24,754,116	2,358,450	4,361,451	113,119,128,000	240,168,000	100%
Desalination	-	-	-	-	-	-	-	100%
<b>Water Treatment</b>	630,774	9,043,809	4,416,704	420,802	778,183	20,183,056,500	42,851,500	100%
<b>Water Distribution</b>	1,877,184	26,914,379	13,144,113	1,252,306	2,315,874	60,064,783,680	172,526,080	100%
<b>Customer Use</b>	-	-	-	-	-	-	-	100%
<b>Waste Water Collection</b>	-	-	-	-	-	-	-	100%
<b>Waste Water Treatment</b>	6,273,885	89,952,676	43,929,980	4,185,431	7,740,064	20,747,265,000	426,215,000	100%
<b>Total</b>	13,889,138	199,137,405	97,252,274	9,265,716	17,134,969	444,414,678,180	943,555,580	

Difference Between Scenarios (Non-Zero Values will only appear)	Reactive Organic Gases	Carbon Monoxide	Nitrogen Oxides	Sulfur Oxides	Particulates <10 Microns	Carbon Dioxide	Energy Use (equivalent Kwh/YR)	California Grid Mix
<b>Sources &amp; Conveyance</b>	664,873	9,532,706	4,655,466	443,550	820,251	21,274,128,000	45,168,000	
Groundwater								
Surface Water								
Reclamation								
Imported	664,873	9,531,706	4,655,466	443,550	820,251	21,274,128,000	45,168,000	
Desalination								
<b>Water Treatment</b>	63,164	905,616	442,273	42,138	77,925	2,021,061,000	4,291,000	
<b>Water Distribution</b>	187,978	2,695,159	1,316,229	125,404	231,908	6,014,783,040	12,770,240	
<b>Customer Use</b>								
<b>Waste Water Collection</b>								
<b>Waste Water Treatment</b>	628,250	9,007,614	4,399,028	419,118	775,069	20,102,280,000	42,680,000	
<b>Total</b>	1,544,264	22,141,995	10,812,995	1,030,209	1,905,152	49,412,252,040	104,909,240	



### End Use Energy Estimation

The model’s methodology for estimating energy embedded in end use for (and energy savings due to) water conservation was significantly modified to reflect the District’s specific conditions. The model assumes that a given volume of water moving through the water supply chain will be partitioned among different end uses (with different end use energy factors); the proportion of water (and thus energy) allocated to each end use by the model is based on the San Diego urban case study as reported in “Energy Down the Drain.” In the District’s case, however, it is already known how the cumulative 300,000 AF of water conserved between FY 92-93 through FY 05-06 is partitioned among water-using end use devices and whether each end use device conserves cold water only or hot water as well. As mentioned earlier, heating water is by far the major source of energy consumption at the end use step for the urban sector<sup>57</sup> (treatment of end use energy estimation for the agricultural sector is discussed in the next paragraph); energy required for pumping, cooling or purifying water at the urban end use step was not considered for this analysis. Thus, only the

five water conservation programs that save hot water were assumed to contribute to urban water conservation end use energy savings.<sup>58</sup>

End use energy savings as estimated by the model were replaced with end use energy savings for the five hot water-saving devices for which the District offers a water conservation program (table 3): low-flow showerheads, faucet aerators, residential high-efficiency clothes washers, CII high-efficiency clothes washers, and pre-rinse sprayers. The annual kWh savings per device, the annual number of rebates (or direct installations or free distributions), the device lifespan, and the number of years the program has been operational, were used to determine annual end use energy savings as well as total end use energy savings (up through FY 05-06) due to the District’s five hot-water saving conservation programs (Table 3). For FY 20-21 staff assumed that a similar suite of hot water-saving programs would be in place as those offered for FY 05-06, leading to an annual end use energy savings similar to the annual end use energy savings for FY 05-06; however, this is likely a conservative assumption as water

Table 3 • ENERGY SAVINGS FROM THE DISTRICT’S HOT WATER CONSERVATION PROGRAMS

Hot water-using end use device	Average annual energy savings per device (kWh/yr/device)	Device lifespan (years)	Number of devices rebated, distributed, or installed since program’s inception
Low-Flow Showerheads	860 <sup>a</sup>	5	112,942
Faucet Aerators	590 <sup>a</sup>	2	94,476
Residential High-Efficiency Clothes Washers	730 <sup>a</sup>	12	58,905
CII High-Efficiency Clothes Washers	1,930 <sup>b</sup>	12	2,425
Low-Flow Pre-Rinse Sprayers	7,630 <sup>c</sup>	5	2,668

<sup>a</sup> From “Energy Down the Drain” ([www.pacinst.org](http://www.pacinst.org)).

<sup>b</sup> From Consortium for Energy Efficiency fact sheet ([www.cee1.org](http://www.cee1.org)).

<sup>c</sup> From “Rinse and Save Phase One Final Report”.



conservation savings (i.e., the number and scope of water conservation programs) and thus energy savings and air emissions reductions are expected to increase each year between now and FY 20-21.

While the primary end use of energy for agriculture is for pumping, on average agricultural water use is approximately 67% less energy-intensive than urban water use, due in large part to less energy demands during the end use step.<sup>59</sup> Estimated agricultural water conservation comprises approximately 2.4% of the 300,000 AF of water the District has saved to date through its water conservation programs. Therefore, the energy intensity of agricultural water use relative to urban water use (expressed as a percentage) and the percentage of total water conservation due to agricultural water conservation were used as adjustment factors to determine the energy savings due to agricultural water conservation.

As discussed earlier, water recycling saves energy by reducing flow through the water supply chain (as does water conservation) but does not specifically save energy at the end use step as is the case for water conservation. Accordingly, the above end use energy modifications made to the model for the water conservation scenarios were not done for the water recycling scenarios because end use energy

estimates “cancel each other out” when the difference between the two recycling model scenarios is estimated (i.e., the volume of total water supplied does not differ between the two scenarios, only the source, recycled water versus imported water). However, it is likely that the end uses (and thus, end use energy) of recycled water differ somewhat from those of other water supply options (imported, groundwater, etc.) because recycled water is not a potable water supply source; however, a detailed analysis of the difference in end uses between water supply sources is beyond the scope of this study.

### Air Emissions Reductions

Air emissions reductions were calculated using air emissions factors, a ratio of air emissions generated (grams/hour) to energy produced (kWh/hour). Air emissions factors for the California Grid (the energy source assumed for this analysis), which are the default values for the model, were obtained from the California Air Resources Board and the California Energy Commission.<sup>60</sup> As mentioned earlier, the air emissions factors were adjusted to reflect the air emissions factors per PG&E energy production data.<sup>61</sup> Table 4 lists the air emissions factors used for this analysis.

Table 4 • AIR EMISSIONS FACTORS

Air Pollutant	Air Emissions Factor (grams/kWh)
Carbon Dioxide	236 <sup>a</sup>
Reactive Organic Gases	0.015 <sup>a</sup>
Carbon Monoxide	0.211 <sup>b</sup>
PM10	0.018 <sup>a</sup>
Sulfur Oxides	0.010 <sup>a</sup>
Nitrogen Oxides	0.103 <sup>a</sup>

<sup>a</sup> From personal communication with PG&E staff. Values are averages for PG&E’s energy portfolio for northern California for 2000-2004.

<sup>b</sup> Default value for model; average for California Energy Grid obtained from California Air Resources Board.



# Notes



- <sup>1</sup> While water conservation is technically a demand management measure and not a “new” water supply source, water conservation provides a “supply” of water that would need to be supplied by an alternative water supply source were water conservation programs not in place. Thus water conservation will be referred to as a water supply source throughout this paper.
- <sup>2</sup> District’s mission statement.
- <sup>3</sup> Gary Wolff, Pacific Institute, and Ronnie Cohen and Barry Nelson, Natural Resources Defense Council, *Energy Down the Drain* (New York: Natural Resources Defense Council, 2004).
- <sup>4</sup> Ibid.
- <sup>5</sup> Ibid.
- <sup>6</sup> Ibid.
- <sup>7</sup> Ibid.
- <sup>8</sup> Ibid.
- <sup>9</sup> Ibid.
- <sup>10</sup> PG&E staff, personal communication. The quantities of air pollutants emitted by a power plant depend on the source used for energy production. For example, natural gas is a “cleaner” (i.e., leads to less air pollution) energy source than coal.
- <sup>11</sup> The terms “air pollutants” and “air emissions” are used interchangeably.
- <sup>12</sup> Bay Area Air Quality Management District <http://www.baaqmd.gov/>
- <sup>13</sup> Ibid.
- <sup>14</sup> Ibid.
- <sup>15</sup> Ibid.
- <sup>16</sup> Wolff, Cohen and Nelson – *Energy Down the Drain*.
- <sup>17</sup> California Department of Water Resources, *Progress on Incorporating Climate Change into Management of California’s Water Resources* (July 2006): <http://baydelta.office.water.ca.gov/climatechange/DWRClimateChangeJuly06.pdf#pagemode=bookmarks &page=1> (accessed on June 6, 2007).
- <sup>18</sup> Ibid.
- <sup>19</sup> Ibid.
- <sup>20</sup> Ibid.
- <sup>21</sup> Ibid.
- <sup>22</sup> Ibid.
- <sup>23</sup> Wolff, Cohen and Nelson – *Energy Down the Drain*.
- <sup>24</sup> Ibid.
- <sup>25</sup> Ibid.
- <sup>26</sup> Ibid.
- <sup>27</sup> California Energy Commission, *California Water-Energy Relationship* (Sacramento: 2005): <http://www.energy.ca.gov/2005publications/CEC-700-2005-011/CEC-700-2005-011SF.PDF#search=%22California's%20WaterEnergy%20Relationship%22> (accessed on June 6, 2007).
- <sup>28</sup> Ibid.



- <sup>29</sup> Ibid.
- <sup>30</sup> Conference proceedings: [http://www.valleywater.org/Water/Water\\_conservation/\\_DWR\\_workshop/index.shtml](http://www.valleywater.org/Water/Water_conservation/_DWR_workshop/index.shtml) (accessed on June 6, 2007).
- <sup>31</sup> The term “embedded energy” refers to the energy required for all steps of the water supply chain: supply/conveyance, treatment, distribution, end use, and wastewater treatment.
- <sup>32</sup> Bob Wilkinson, University of California Santa Barbara, *Methodology for Analysis of the Energy Intensity of California’s Water Systems* (Santa Barbara, 2000). [http://www.es.ucsb.edu/faculty/Wilkinson\\_EWRPT01%20DOC.pdf](http://www.es.ucsb.edu/faculty/Wilkinson_EWRPT01%20DOC.pdf) (accessed on June 6, 2007).
- <sup>33</sup> Gary Wolff, Pacific Institute, *Water to Air Models*. (Oakland: 2004): [http://www.pacinst.org/resources/water\\_to\\_air\\_models/index.htm](http://www.pacinst.org/resources/water_to_air_models/index.htm) (accessed on June 6, 2007).
- <sup>34</sup> Ibid.
- <sup>35</sup> The average California household uses 6,750 kWh of electricity per year. California Energy Consumption by Sector: [http://energy.ca.gov/electricity/consumption\\_by\\_sector.html](http://energy.ca.gov/electricity/consumption_by_sector.html) (accessed on June 6, 2007).
- <sup>36</sup> Assumes groundwater is not treated nor does it require energy for distribution (i.e., groundwater pumps produce sufficient energy for distribution). Assumes conveyance of surface water is gravity fed. Assumes there is no advanced treatment of recycled water. Values for recycled water are incremental; that is, they represent any energy inputs incurred beyond energy required to treat wastewater to the tertiary treatment level. For the District’s systems, this means pumping through the recycled water distribution system and treating the wastewater as recycled water treatment enters the waste water treatment plant for the second time (the first time being when it was produced).
- <sup>37</sup> Wolff, Cohen and Nelson – *Energy Down the Drain*. As is noted in the appendix, these default end use values were not used in determining end use energy savings for the District; instead, staff used rebate/installation program data to obtain a more accurate and District-specific estimate of end use energy savings.



- <sup>38</sup> EPA provides a website for converting masses of greenhouse gases into quantities that are more easily related to, such as “number of cars removed from the roads for one year” or “number of barrels of oil”: <http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterToolsCalculators.html#%3C%3E%3EEquivalency%20Calculators%3C%2F%3E> (accessed on June 6, 2007).
- <sup>39</sup> Bay Area Air Quality Management District, personal communication.
- <sup>40</sup> South Coast Air Quality Management District website: <http://www.aqmd.gov/>.
- <sup>41</sup> PG&E staff, personal communication. While coal currently comprises 1.7% of PG&E’s energy portfolio it is a less clean source of energy than most other energy sources and is not being considered as a power source for PG&E’s long-term energy plan, which has a goal of 20% eligible renewable energy sources (solar, wind, small hydropower, geothermal, biomass) by 2010. However, energy purchased on the open market (especially during the next five to ten years) to meet additional demand may come from an older power plant using an energy source (most likely natural gas) less efficiently.
- <sup>42</sup> Wolff, Cohen, and Nelson – Energy Down the Drain.
- <sup>43</sup> Ibid.
- <sup>44</sup> Santa Clara Valley Water District (with M.Cubed, Farrand Research, Inc., Western Wats, Inc. and Conservision Consulting, LLC.), Santa Clara County Residential Water Use Baseline Study (San Jose: 2004).
- <sup>45</sup> Formula for end use energy savings: 288,500 showerheads X 860 kWh savings/year/showerhead X 5 year lifespan for each showerhead = 1,240,550,000 kWh. The Water to Air model was used to estimate energy savings from the other four steps of the water supply chain. Formula for water savings: 288,500 showerheads X 2000 gal savings/year/showerhead X 5 year lifespan for each showerhead X 1 AF/325,852 gal = 8854 AF
- <sup>46</sup> Formula for end use energy savings: 307,910 clothes washers X 730 kWh/year/clothes washer X 12 year lifespan for each clothes washer = 2,697,291,600 kWh. The Water to Air model was used to estimate energy savings from the other four steps of the water supply chain. Formula for water savings: 307,910 clothes washers X 6,400 water savings/year/clothes washer X 12 year lifespan for each clothes washer X 1AF/325,852 gal = 72,571 AF.
- <sup>47</sup> Fisher-Nickel Food Service Technology Center and Koeller and Company, Evaluating the Water Savings Potential of Commercial Connectionless Food Steamers, prepared for Metropolitan Water District and East Bay Municipal Utility District (2005): [http://www.cuwcc.org/Comm\\_Food\\_Service/Steamer\\_Field\\_Study\\_Final\\_Report\\_June-2005.pdf](http://www.cuwcc.org/Comm_Food_Service/Steamer_Field_Study_Final_Report_June-2005.pdf) (accessed on June 6, 2007).



- <sup>48</sup> Formula for end use energy savings: 2,974 restaurants and CII kitchens X 1 steamer/restaurant X 19,000 kWh savings/year/steamer X 10 year lifespan for each connectionless steamer = 565,060,000 kWh. The Water to Air model was used to estimate energy savings from the other four steps of the water supply chain. Formula for water savings: 2,974 restaurants and CII kitchens X 1 steamer/restaurant X 224,400 gal water savings/year/steamer X 10 year lifespan for each connectionless steamer X 1 AF/ 325,852 gal = 20,000 AF
- <sup>49</sup> Wolff, Cohen, and Nelson – Energy Down the Drain.
- <sup>50</sup> Pacific Institute staff, personal communication.
- <sup>51</sup> Sustainable Silicon Valley Mission Statement: <http://www.sustainablesiliconvalley.org/> (accessed on June 6, 2007).
- <sup>52</sup> Wolff, Cohen, and Nelson – Energy Down the Drain.
- <sup>53</sup> Pacific Institute staff, personal communication. Santa Clara Valley Water District staff, personal communication.
- <sup>54</sup> PG&E staff, personal communication.
- <sup>55</sup> Ibid.
- <sup>56</sup> Ibid.
- <sup>57</sup> Wolff, Cohen, and Nelson – Energy Down the Drain.
- <sup>58</sup> End use energy savings due to passive water conservation were not considered. Energy savings due to the other four steps of the water supply chain for passive water conservation were accounted for in this analysis.
- <sup>59</sup> California Energy Commission, California Water-Energy Relationship (Sacramento: 2005): <http://www.energy.ca.gov/2005publications/CEC-700-2005-011/CEC-700-2005-011-SF.PDF#search=%22California's%20Water-Energy%20Relationship%22> (accessed on June 6, 2007).
- <sup>60</sup> Wolff–Water to Air Models.
- <sup>61</sup> PG&E staff, personal communication.



**5750 Almaden Expressway • San Jose, CA 95118 • (408) 265-2600 • [www.valleywater.org](http://www.valleywater.org)**



Printed on recycled paper using soy-based inks. 06/07 RG