Attachment 2

Within System (lifetime)		
System Water Savings:	147.105	MG/$M
System, End-Use & EE/RE Savings:	64,099,721	kWh/$M
System, End-Use & EE/RE GHG Emission Reductions:	19,128,608	kg CO_2e/$M

Grand Total (lifetime)		
Water Savings:	367.360	MG
Energy Savings:	161,116,320	kWh
GHG Emissions Reduction:	48,124,643	kg CO_2e

System Summary

	Total Project Cost	Water Savings		Energy Savings		GHG Reduction	
		Annual	Lifetime	Annual	Lifetime	Annual	Lifetime
Project 1	$ 2,497,263	22.960 MG/year	367.360 MG	234,192 kWh/year	3,747,072 kWh	79,859 kg CO_2e/year	1,277,752 kg CO_2e
Project 2	$ -	0.000 MG/year	0.000 MG	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 3	$ -	0.000 MG/year	0.000 MG	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 4	$ -	0.000 MG/year	0.000 MG	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 5	$ -	0.000 MG/year	0.000 MG	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 6	$ -	0.000 MG/year	0.000 MG	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 7	$ -	0.000 MG/year	0.000 MG	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 8	$ -	0.000 MG/year	0.000 MG	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 9	$ -	0.000 MG/year	0.000 MG	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 10	$ -	0.000 MG/year	0.000 MG	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Total	**$ 2,497,263**	**22.960 MG/year**	**367.360 MG**	**234,192 kWh/year**	**3,747,072 kWh**	**79,859 kg CO_2e/year**	**1,277,752 kg CO_2e**

Imported Water Summary

	Energy Savings		GHG Reduction	
	Annual	Lifetime	Annual	Lifetime
Project 1	65,154 kWh/year	1,042,457 kWh	22,217 kg CO_2e/year	355,478 kg CO_2e
Project 2	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 3	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 4	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 5	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 6	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 7	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 8	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 9	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 10	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Total	**65,154 kWh/year**	**1,042,457 kWh**	**22,217 kg CO_2e/year**	**355,478 kg CO_2e**

Hot Water Heating System Summary

	Energy Savings		GHG Reduction	
	Annual	Lifetime	Annual	Lifetime
Project 1	2,662,690 kWh/year	42,603,047 kWh	481,976 kg CO_2e/year	7,711,617 kg CO_2e
Project 2	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 3	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 4	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 5	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 6	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 7	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 8	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 9	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Project 10	0 kWh/year	0 kWh	0 kg CO_2e/year	0 kg CO_2e
Total	**2,662,690 kWh/year**	**42,603,047 kWh**	**481,976 kg CO_2e/year**	**7,711,617 kg CO_2e**

Energy Efficiency and Renewable Energy (EE/RE) Summary

	Energy Savings		GHG Reduction			
	Annual	Lifetime	Annual		Lifetime	
Project 1	7,107,734 kWh/year	113,723,744 kWh	2,423,737	kg CO_2e/year	38,779,797	kg CO_2e
Project 2	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 3	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 4	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 5	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 6	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 7	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 8	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 9	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 10	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Total	**7,107,734 kWh/year**	**113,723,744 kWh**	**2,423,737**	**kg CO_2e/year**	**38,779,797**	**kg CO_2e**

Total System Summary (System + Water Heating + EE/RE)

	Water Savings				Energy Savings		GHG Reduction			
	Annual		Lifetime		Annual	Lifetime	Annual		Lifetime	
Project 1	22.960	MG/year	367.360	MG	10,004,616 kWh/year	160,073,863 kWh	2,985,573	kg CO_2e/year	47,769,165	kg CO_2e
Project 2	0.000	MG/year	0.000	MG	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 3	0.000	MG/year	0.000	MG	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 4	0.000	MG/year	0.000	MG	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 5	0.000	MG/year	0.000	MG	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 6	0.000	MG/year	0.000	MG	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 7	0.000	MG/year	0.000	MG	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 8	0.000	MG/year	0.000	MG	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 9	0.000	MG/year	0.000	MG	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 10	0.000	MG/year	0.000	MG	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Total	**22.960**	**MG/year**	**367.360**	**MG**	**10,004,616 kWh/year**	**160,073,863 kWh**	**2,985,573**	**kg CO_2e/year**	**47,769,165**	**kg CO_2e**

Combined Summary (System + Imports + Water Heating + EE/RE)

	Water Savings				Energy Savings		GHG Reduction			
	Annual		Lifetime		Annual	Lifetime	Annual		Lifetime	
Project 1	22.960	MG/year	367.360	MG	10,069,770 kWh/year	161,116,320 kWh	3,007,790	kg CO_2e/year	48,124,643	kg CO_2e
Project 2	0.000	MG/year	0.000	MG	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 3	0.000	MG/year	0.000	MG	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 4	0.000	MG/year	0.000	MG	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 5	0.000	MG/year	0.000	MG	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 6	0.000	MG/year	0.000	MG	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 7	0.000	MG/year	0.000	MG	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 8	0.000	MG/year	0.000	MG	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 9	0.000	MG/year	0.000	MG	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Project 10	0.000	MG/year	0.000	MG	0 kWh/year	0 kWh	0	kg CO_2e/year	0	kg CO_2e
Total	**22.960**	**MG/year**	**367.360**	**MG**	**10,069,770 kWh/year**	**161,116,320 kWh**	**3,007,790**	**kg CO_2e/year**	**48,124,643**	**kg CO_2e**

Attachment 2

Estimate of Water Savings, Energy Savings, and GHG Emissions Reduction

Project Name: **Water-Energy Community Action Network (WE CAN)**
Total Project Cost: **$2,497,263**

Project Assumptions			
Step 1:	Enter the baseline (pre-project) volume of water associated with the project	**22.96**	MG/year
Step 2:	Enter the volume of water that will be delivered after the project is implemented.	**0**	MG/year
Step 3:	Enter the volume of hot water saved from the project's electric water heating system (the summation of step 3 and step 4 must not exceed annual volume of water savings). If not applicable, enter "0".	**0**	MG/year
Step 4:	Enter the volume of hot water saved from the project's natural gas water heating system (the summation of step 3 and step 4 must not exceed annual volume of water savings). If not applicable, enter "0".	**11.52**	MG/year
Step 5:	Enter the useful life in years for the project	**16**	years
Step 6:	Enter the percentage of water that is imported	**30%**	
Step 7:	Enter the Energy Intensity (EI) of the System associated with the project's water savings	**10200**	kWh/MG
Step 8:	Enter the total output emission rate specific to the power supplier or use the default value of 0.278	**0.341**	kg CO_2e/kWh
Step 9:	Enter EI associated with the Supply and Conveyance segment of the imported water or enter "0" if imported water is not applicable	**9459**	kWh/MG
Step 10:	Enter any additional annual energy savings from energy efficiency and renewable energy (EE/RE), etc.	**7107734**	kWh/year

*****Note: on a separate sheet provide the basis for the estimates and information sources for factors entered*****

Note: values below are determined from the above Project Asssumptions

			Units
Water Savings			
1)	Annual volume of water savings within System	22.96	MG/year
2)	Annual volume of imported water savings	6.888	MG/year
3)	Annual volume of hot water heating system savings	11.52	MG/year
4)	Lifetime volume of water savings within System	367.36	MG
5)	Lifetime volume of imported water savings	110.208	MG
6)	Lifetime volume of hot water heating system savings	184.32	MG
Energy Savings			
1)	Annual energy savings within System	234,192	kWh/year
2)	Annual energy savings from imported water	65,154	kWh/year
3)	Annual energy savings from electric hot water heating system	0	kWh/year
4)	Annual energy savings from natural gas hot water heating system (used to calculate total energy saving)	2,662,690	kWh/year
5)	Total annual energy savings from electric and natural gas hot water heating systems	2,662,690	kWh/year
6)	Annual energy savings from natural gas hot water heating system (used to calculate GHG emmission)	90,939	therms/year
7)	Lifetime energy savings within System	3,747,072	kWh
8)	Lifetime energy savings from imported water	1,042,457	kWh
9)	Lifetime energy savings from electric hot water heating system	0	kWh
10)	Lifetime energy savings from natural gas hot water heating system	42,603,047	kWh
11)	Total lifetime energy savings from electric and natural gas hot water heating systems	42,603,047	kWh
12)	Lifetime energy savings from natural gas water heating system	1,455,022	therms
13)	Additional lifetime energy savings from Energy Efficiency and Renewable Energy (EE/RE), etc.	113,723,744	kWh
GHG Emission Reductions			
1)	Annual GHG emission reductions within System	79,859	kg CO_2e/year
2)	Annual imported GHG emission reductions	22,217	kg CO_2e/year
3)	Annual GHG emission reductions from electric hot water heating	0	kg CO_2e/year
4)	Annual GHG emission reductions from natural gas hot water heating system	481,976	kg CO_2e/year
5)	Total annual GHG reductions from electric and natural gas hot water heating system	481,976	kg CO_2e/year
6)	Lifetime GHG emission reductions within System	1,277,752	kg CO_2e
7)	Lifetime GHG emission reductions from imported water	355,478	kg CO_2e
8)	Lifetime GHG emission reductions from electric heating system	0	kg CO_2e
9)	Lifetime GHG emission reductions from natural gas water heating system	7,711,617	kg CO_2e
10)	Total lifetime GHG emission reductions from electric and natural gas hot water heating systems	7,711,617	kg CO_2e
11)	Additional annual GHG emission reductions from Energy Efficiency and Renewable Energy (EE/RE), etc.	2,423,737	kg CO_2e/year
12)	Additional lifetime GHG emission reductions from Energy Efficiency and Renewable Energy (EE/RE), etc.	38,779,797	kg CO_2e
Project Summary			
	Total annual water savings	22.96	MG/year
	Total lifetime water savings	367.36	MG
	Total annual energy savings	10,069,770	kWh/year
	Total lifetime energy savings	161,116,320	kWh
	Total annual GHG emission reductions	3,007,790	kg CO_2e/year
	Total lifetime GHG emission reductions	48,124,643	kg CO_2e

Attachment 2 - Calculator Supporting Information

Steps for Calculator	Item	Amount	Metric	Document No.	Explanation
	Total Cost	$ **2,497,263**	Dollars		Total cost calculation, see Attachment 4 Budget.
Step 1	Baseline Volume of Water	**22,960,000**	Gallons		Assume no benefits from project, prior to project implementation. Benefits Per Year/Volume of Water delivered calculation provided below in Water Saving Retrofit and Hot Water Savings Step 3: Calculation = (11,440,000+11,520,000)
	Estimation of San Bernardino County, Orange County and Riverside County Water Saving Retrofit (Retrofit Subproject)				
	DAC Residential Homes	260	Homes		Total residential homes served by subproject.
	Landscaped Portion Per Home	1,000	SF		Total area of turfed grass per home.
	Total Area Landscaped	260,000	SF		Total area of turfed grass for the subproject
	Benefits per SF Per Year	44	Gallons	1	See Supporting Document - Comprehensive Landscape Water Use Efficiency Program Presentation, MWDOC, 10/3/13.
	Subtotal Benefits Per Year/Volume of Water Delivered	11,440,000	Gallons		Calculation = (260,000*44)
	Savings Period	22	Years	2	See Supporting Document - SAWPA IRWM 2014 Drought Solicitation Application.
Step 2	Subtotal Benefits Per Year/Volume of Water Delivered	-	Gallons		Assume no benefits from project, prior to project implementation.
Step 3	Hot Water Saved Electric	-	Gallons		Assumed DAC homes reliant on natural gas water heaters.
Step 4	Hot Water Saved Natural Gas	**11,520,000**	Gallons		Assumed DAC homes reliant on natural gas water heaters.
	Annual benefits per Low Flow Showerhead	3,600	Gallons	3	See Supporting Document - U.S. Environmental Protection Agency WaterSense Calculator
	Total Showers Installed	3,200	Showerhead Units	4	See Supporting Document - Orange County & Riverside County Energy Saving Retrofit (table).
Step 5	Average Savings Period	**16**	Years		Average of savings periods of subprojects calculation provided below.
	Estimation of Average Savings Period				
	Savings Period San Bernardino County Whole House Energy Efficiency Retrofit	14	Years	5, 6, 7	See Supporting Document - Mr. Appliance Appliance Life Expectancy, California State Controllers Office Useful Life of Fixed Assets from California State Controllers Office, and Expected Useful Life Summary Table.
	Savings Period Orange County and Riverside County Energy Saving Measures Benefits per year	12	Years	4	See Supporting Document - Orange County & Riverside County Energy Saving Retrofit (table).
	Savings Period San Bernardino County, Orange County and Riverside County Water Saving Retrofit	22	Years	2	See Supporting Document - SAWPA IRWM 2014 Drought Solicitation Application.
	Average Savings Period	16	Years		Calculation = (14+12+22/3)
Step 6	Percentage of Imported Water	**30%**	Percent	8	See Supporting Document - Santa Ana River Watershed IRWM Plan (One Water One Watershed 2.0, Chapter 5.4 Water Resource Optimization)
Step 7	Energy Intensity of the System	**10,200**	kWh/MG	9	See Supporting Document - CEC California's Water-Energy Relationship. Southern California EI for Supply/Conveyance, Treatment and Distribution.
Step 8	Total Output Emissions Rate	**0.341**	kg CO2e/kWh		Total Output Emissions Rate calculation provided below.
	Estimation of Total Output Emissions Rate				
	Scope 1 Emissions	*6,200,000*	*metric tons CO2e*	10, 11	See Supporting Document - Southern California Edison Corporate Responsibility Report (2013) and Southern California Edison Santa Ana Watershed Service Area (map).
	Scope 2 Emissions	*2,000,000*	*metric tons CO2e*	10, 11	ibid.
	Scope 3 Emissions	*21,600,000*	*metric tons CO2e*	10, 11	ibid.
	Sum	*29,800,000*	*metric tons CO2e*	10, 11	ibid.
	Conversion to kg	*29,800,000,000*	*kg CO2e*		Calculation = ((6,200,000+2,000,000+21,600,000)/0.001)
	Output	*87,397,000,000*	*kWh*	10, 11	ibid.
	Total Output Emission Rate	*0.341*	*kg CO2e/kWh*		Calculation = (29,800,000,000/87,397,000,000)

Step 9	Supply/Conveyance Imported Water Energy Intensity	**9,459**	kWh/MG		Supply/Conveyance Imported Water Energy Intensity calculation provided below.
	Estimation of Supply/Conveyance Imported Water Energy Intensity				
	Colorado River Aqueduct (CRA)	*6,066*	*kWh/MG*		From Table 6 of PSP/Guidelines.
	State Water Project	*13,606*	*kWh/MG*		Ibid.
	Santa Ana River Watershed CRA Reliance	*55%*	*Percent*		Average of years 2000-2010 (verbal communication, Metropolitan Water District Staff)
	Santa Ana River Watershed SWP Reliance	*45%*	*Percent*		Ibid.
	Weighted Average	*9,459*	*kWh/MG*		Calculation = (13,606*45%)+(6,066*55%)
Step 10	Additional Energy Savings	**7,107,734**	kWh/year		Additional Energy Savings calculation provided below.
	Estimation of Additional Energy Savings				
	DAC Residential Homes - San Bernardino County Whole House Energy Efficiency Retrofit	103	Homes		Total residential homes served by subproject.
	Benefits per Home - San Bernardino County Whole House Energy Efficiency Retrofit	2,193	kWh	12	See Supporting Document - U.S. Department of Energy Home Energy Saver Report.
	Benefits per Home - San Bernardino County Whole House Energy Efficiency Retrofit	225	Therms		See Supporting Document - U.S. Department of Energy Home Energy Saver Report.
	Benefits Per Year - San Bernardino County Whole House Energy Efficiency Retrofit	2,258	kWh	13	Calculation =(2,193+(225*0.29)). Used therm to kWh conversion from Center Point Energy.
	Benefits Per Year - Orange County and Riverside County Energy Saving Measures	6,875,134	kWh	11	See Supporting Document - Orange County & Riverside County Energy Saving Retrofit (table).
	Subtotal Benefits Per Year	7,107,734	kWh		Calculation =(2,258*103)+6,875,134

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Document 1

Get a CLWUE!

The Comprehensive Landscape Water Use Efficiently Program

October 3, 2013

Melissa Baum-Haley, Ph.D.
Water Use Efficiency Programs Programs Specialist
Municipal Water District of Orange County

MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

Municipal Water District or Orange County

WHO WE ARE

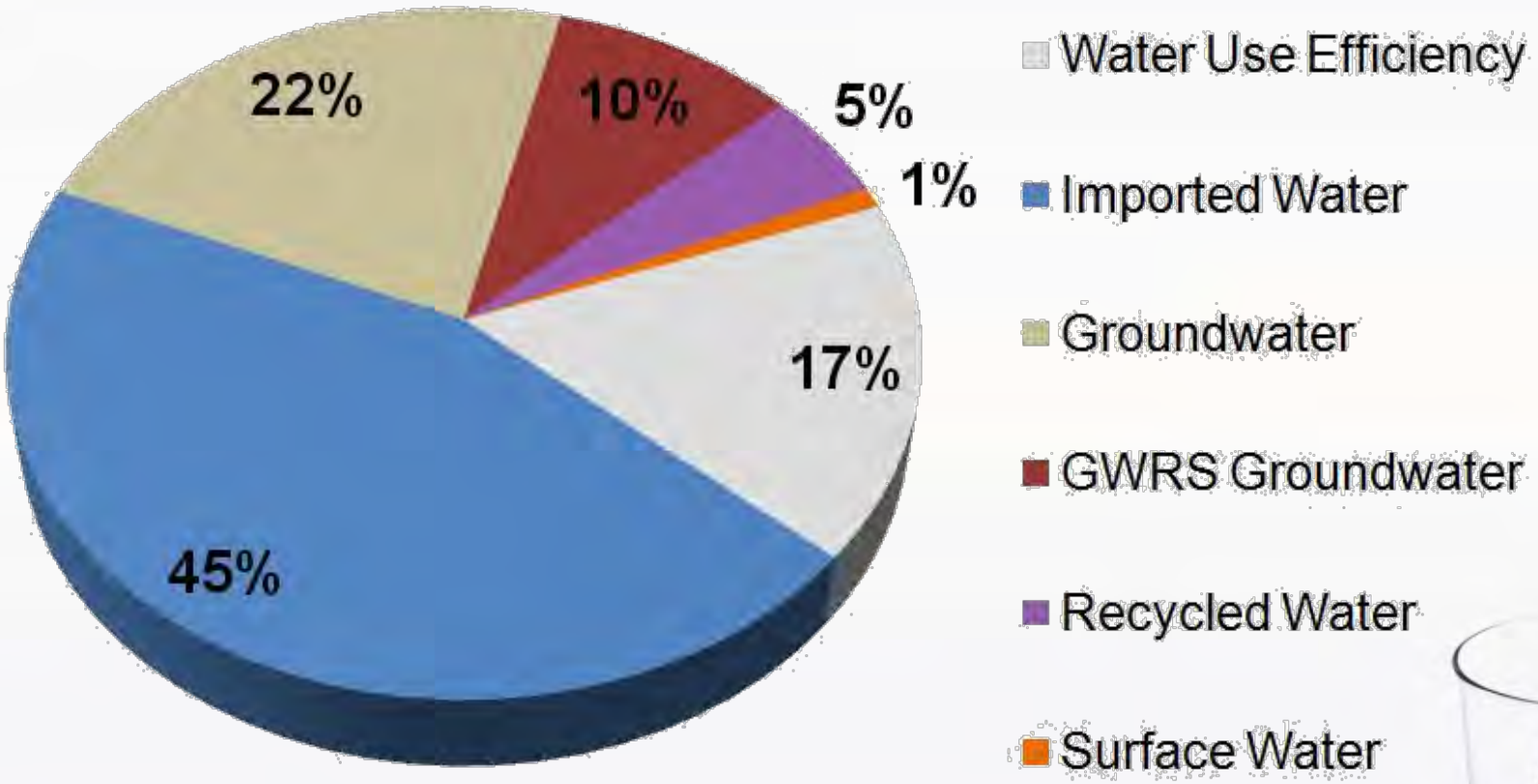
MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

Municipal Water District of Orange County

- Wholesale supplier and regional planner to 28 client cities and water agencies
- Governed by seven-member elected board of directors
- Member agency of Metropolitan Water District of Southern California
- Service area: 600 square miles
- Water demand: 668,000 AFY
  - Imported supply
  - Local supplies
- Population: 2.3 million

MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

Where Orange County Gets its Water



MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

Program Funding Provided By:

MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

DEPARTMENT OF WATER RESOURCES
STATE OF CALIFORNIA

NRCS

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

The Family of Orange County Water Agencies

MWD
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

The Problem

Too much excess water!

System inefficiencies!

Too much runoff!

Lack of maintenance!

Lack of management!

Lack of communication!

MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

The Solution

REBATES & INCENTIVES

MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

SMARTIMER™
REBATE PROGRAM

Receive money back when you upgrade to "smart" technology that fully automates landscape watering, based on the weather and water needs of your plants.

Smart Timer Rebate Program

- **Provides rebate incentives to install automated self-adjusting weather based irrigation controllers & soil moisture sensors**

- **Residential Smart Timer Rebate Levels:**
  - **$80 to $380 per controller installed**
- **Commercial Smart Timer Rebate Levels:**
  - **$25/station up to clock capacity**

MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

Rotating Nozzle Rebate Program

- Distribution Uniformity Improvement Incentive
- Replacement nozzle for spray heads
- Save 6,600 gallons per nozzle over 5 years
  - $4 to $5 per nozzle
- 15 nozzle minimum per site for common areas (commercial)

MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

Turf Removal Rebate Program

- Turf removal with replacement by California Friendly plants and permeable surfaces
- Rebate amount in Orange County
  - $1.00 to $2.00 per square foot
- Water savings are estimated at 44 gallons per square foot per year
- For more information visit:
  - www.mwdoc.com/services/turf-removal

MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

Spray to Drip Pilot Program

- Spray irrigation with replacement by embedded emitter drip tubing
  - Criteria includes pressure regulation and filters
- Rebate amount in Orange County
  - $0.20 to $0.40 per square foot
  - can be in addition to turf removal

MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

Public Spaces WSL

- **The Program specifically targets the implementation of comprehensive landscape improvements for publicly owned and other commercial landscape properties**
  - **Highly visible sites**
  - **Encourage the new norm**
  - **Cost share program**

Pay for Performance Programs

- Water Savings Incentive Program
- Hotel Program
- CII Pay-for-Performance

- Focuses on Large landscapes
- Incentive amount paid based on actual water savings during a one year monitoring period
  - Can include a suite of device changes, plant changes, increased management, or any other practice

MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

INFORMATION TOOLS
&
EDUCATIONAL OUTREACH

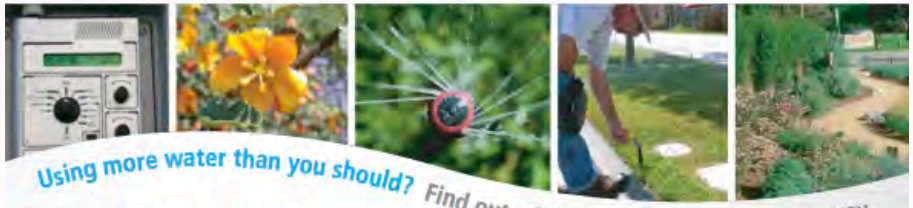
MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

Landscape Surveys

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

Landscape Irrigation Survey

For Commercial, Industrial, Institutional and Common Area Landscapes



Using more water than you should? Find out with a landscape irrigation survey.

HOW IT WORKS

A certified landscape irrigation auditor will survey and provide written recommendations for qualifying non-residential properties within Metropolitan's 5,200 square-mile service area **at no cost**. To participate, properties must have a minimum of one acre of irrigated land. Eligible landscapes include commercial and industrial sites, homeowner association common areas, and institutional sites like schools, parks and government facilities.

Surveys are scheduled on a first-come, first-served basis. To request a survey, please complete the online application at bewaterwise.com®. Funding is limited and submitting an application does not guarantee a survey will be provided.

CONTACT

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dcotton@mwdh2o.com

WHAT TO EXPECT

The property owner, manager or authorized representative with access to the irrigation controllers must be present during the survey. The certified landscape irrigation auditor will conduct a comprehensive review of the irrigation system including:

- System pressure
- Controllers
- Site conditions and irrigation scheduling
- Issues that cause higher water use, such as valve malfunctions, high or low pressure, sprinkler misalignment, poor drainage, breaks and leaks, runoff, etc.

Participants will receive a written report that includes:

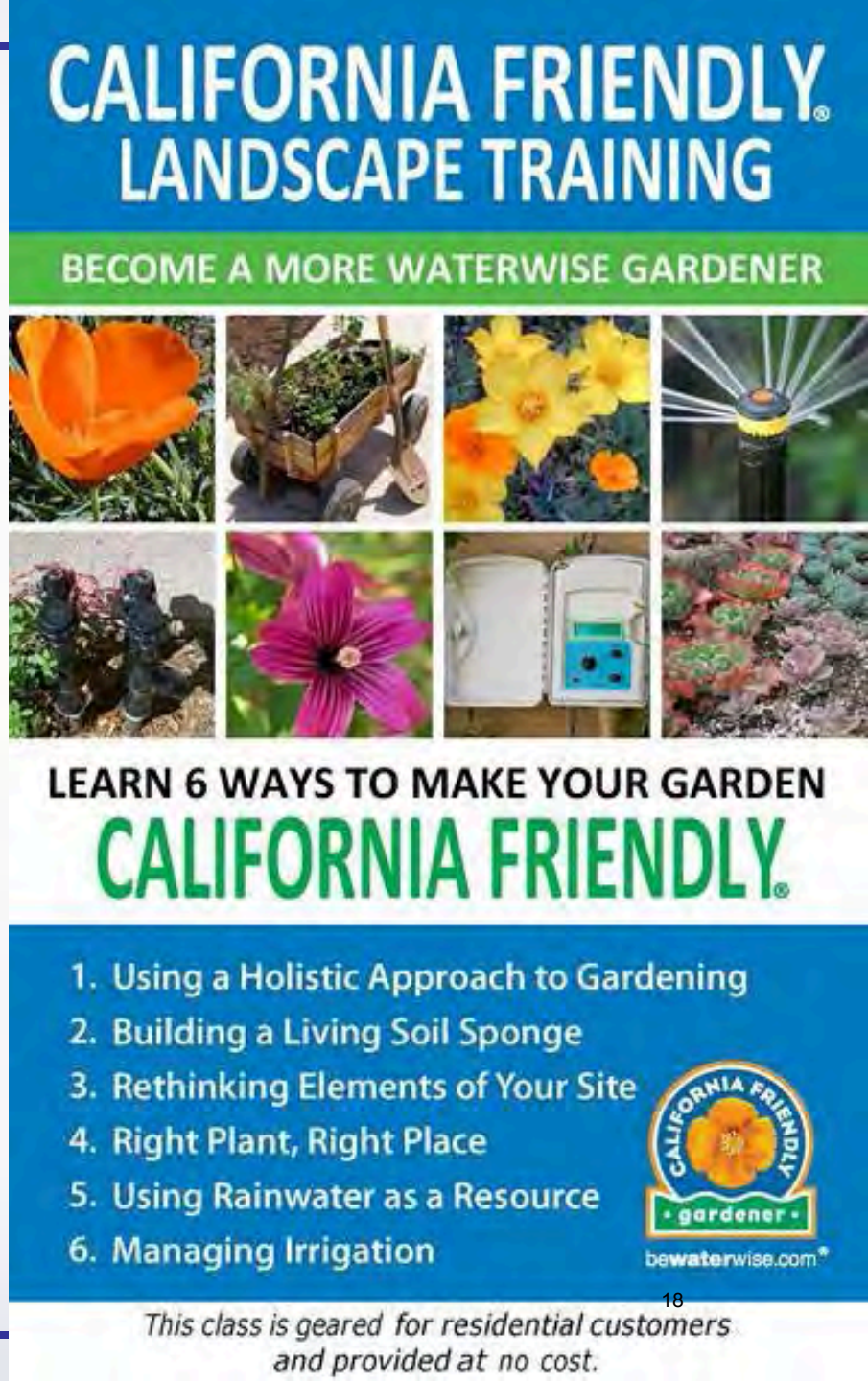
- Data collected during the survey
- Recommendations for improving the site's irrigation efficiency including system repairs, equipment updates, and irrigation scheduling
- Information about available financial incentives to help with the cost of recommended improvements

bewaterwise.com®

MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

California Friendly Landscape Classes

- Encourage participants to think of their property as a watershed
- Introduction to water use efficiency in the landscape
- Great opportunity to "show & tell"



MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

Rain Barrels

- Encourage the perspective that rain is a water source
- Gateway product
- Visual prompt
- Rebate amount
  - $75 per barrel

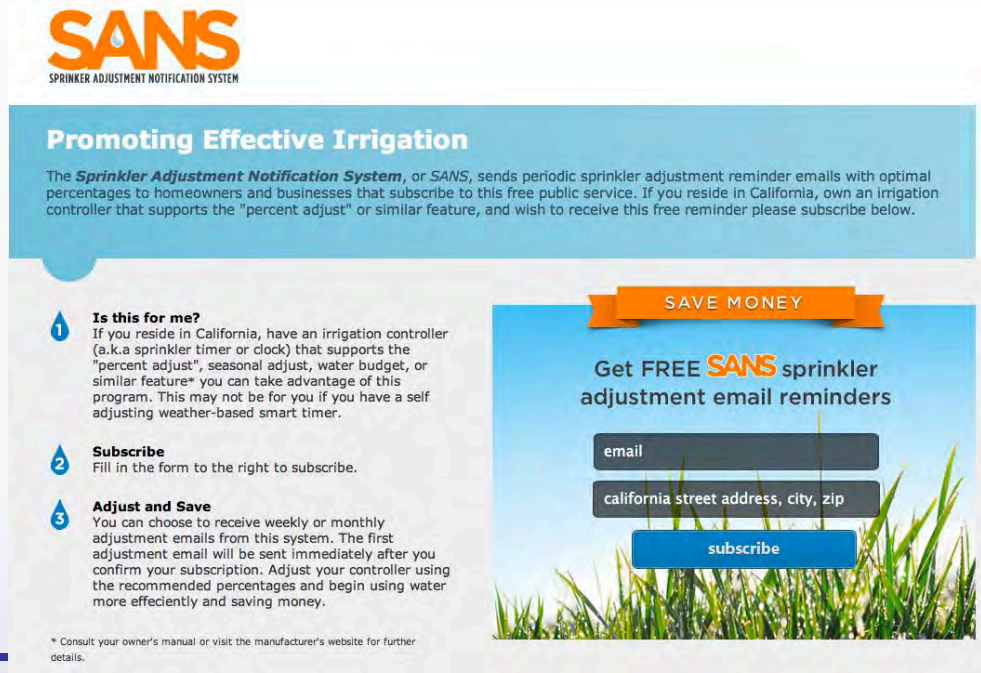
MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

Water Smart Home Certification Program

- Participating in a free home water survey will score the home's water use efficiency and identify potential water savings needed.
- Recommendations will include money- and water-saving rebates and no-cost activities that can help participants become more water efficient.

California Sprinkler Adjustment Notification System

- **Sends periodic sprinkler adjustment reminder emails**
  - **with optimal percentages for conventional timers with the percent adjust feature**
- **Free public service**
- **Avenue for marketing other programs and education**



SANS
SPRINKER ADJUSTMENT NOTIFICATION SYSTEM

Promoting Effective Irrigation

The ***Sprinkler Adjustment Notification System***, or *SANS*, sends periodic sprinkler adjustment reminder emails with optimal percentages to homeowners and businesses that subscribe to this free public service. If you reside in California, own an irrigation controller that supports the "percent adjust" or similar feature, and wish to receive this free reminder please subscribe below.

1. **Is this for me?**
If you reside in California, have an irrigation controller (a.k.a sprinkler timer or clock) that supports the "percent adjust", seasonal adjust, water budget, or similar feature* you can take advantage of this program. This may not be for you if you have a self adjusting weather-based smart timer.

2. **Subscribe**
Fill in the form to the right to subscribe.

3. **Adjust and Save**
You can choose to receive weekly or monthly adjustment emails from this system. The first adjustment email will be sent immediately after you confirm your subscription. Adjust your controller using the recommended percentages and begin using water more effeciently and saving money.

* Consult your owner's manual or visit the manufacturer's website for further details.

SAVE MONEY

Get FREE SANS sprinkler adjustment email reminders

email

california street address, city, zip

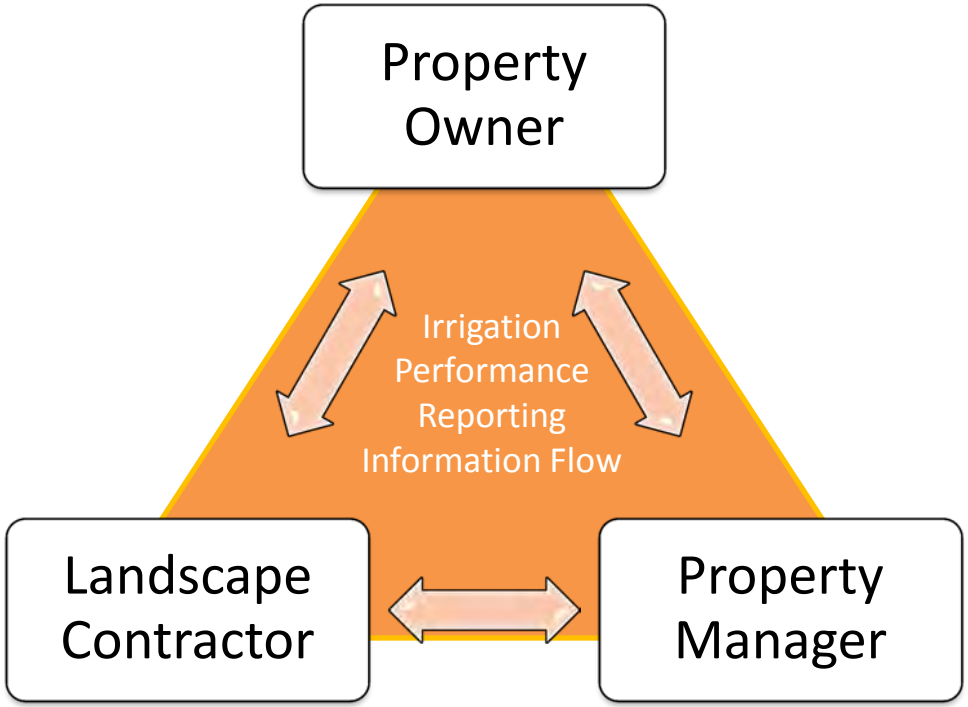
subscribe

MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

Stormwater Partnership

- **MS4 Permit Compliance**
- **Public Educational Informational Campaign Partnership**

Communication Tools



Water Smart Landscape Program (WSLP)

Formerly: Landscape Performance Certification Program

- A Free Program that establishes Landscape Irrigation Budgets for dedicated landscape meters
  - Scientific calculation of the annual, monthly or weekly water requirements
- Provides monthly irrigation performance reports to landscape contractors, property managers and property owners

Performance-Based Irrigation Management Contract

An outcome based approach to contracting that uses irrigation scheduling performance measures to define the minimum irrigation efficiency standards that must be met by the contractor.

Intended Users

- Commercial Property Owners
- Home Ownership Associations
- Landscape Maintenance Contractors
- Community Managers
- Municipalities

Adaptable/Customizable/Flexible

ROI Calculator

- Technical education
- Help prioritize sites for upgrades
- Identify potential expense reductions
  - O&M and Capital
- Facilitate communication among stakeholders
- Provide a financial analysis for landscaping and water management

MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

INSPECTIONS, MONITORING & IMPACT EVALUATIONS

MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

Inspections, Monitoring, & Evaluations

- The majority of our rebates require 100% site inspections to verify installation
- Pay for performance projects are monitored
- Each program has an Evaluation
  - Process – how the program functions
  - Impact – effectiveness of program (water savings, reduction of runoff, etc.)

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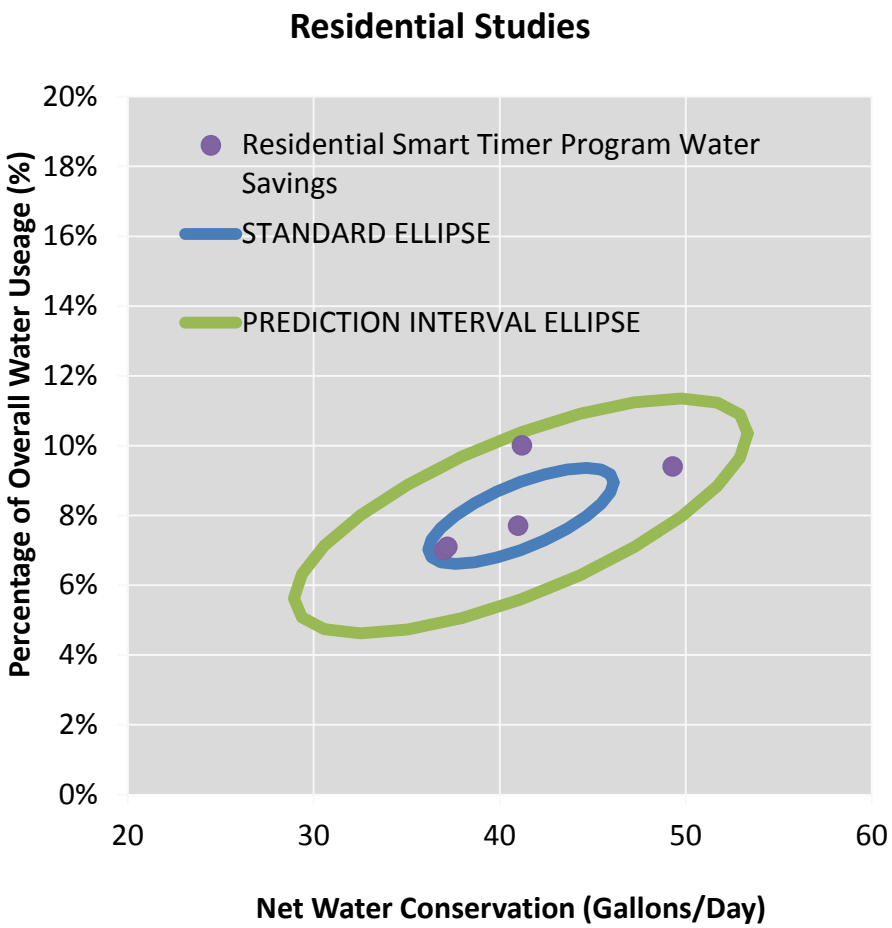
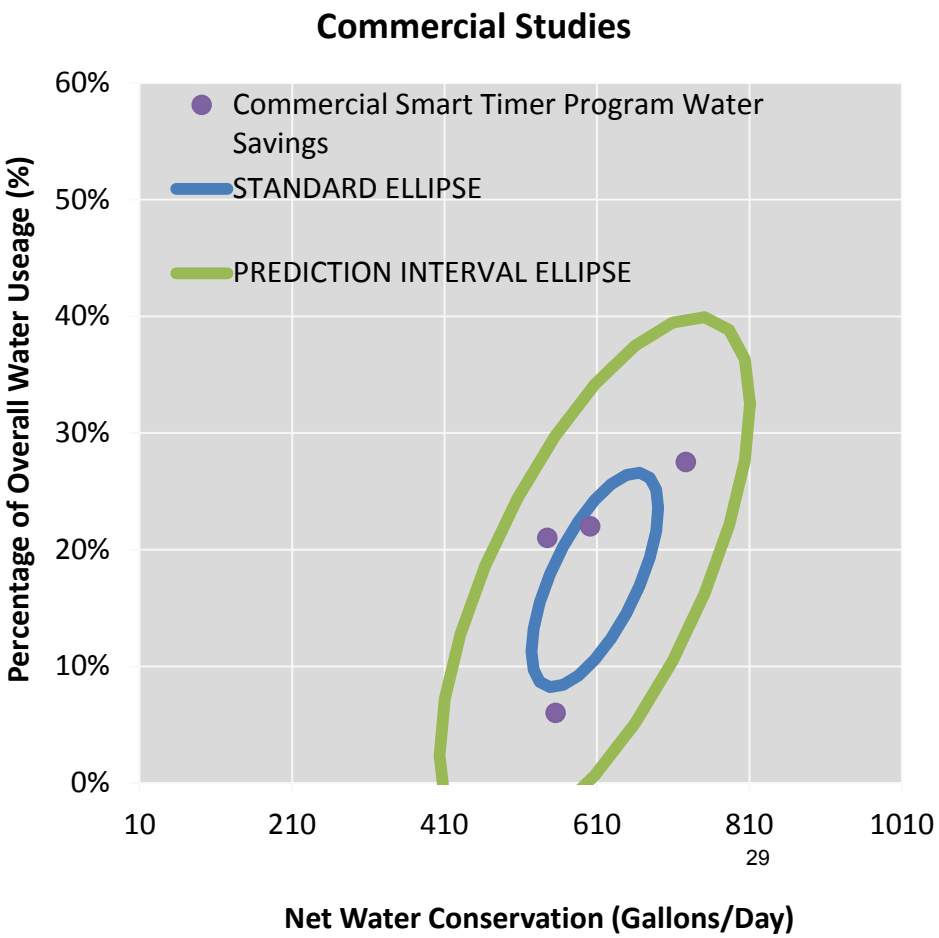
Impact Evaluation Results

Smart Timers





Water Use Efficiency Master Plan

- Comprehensive look at all programs offered in Orange County
  - Benefit-cost ratio
  - Productions levels
- How to best meet our conservation goals

MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

Where do we go from here?

- Can’t look ahead without looking back
  - Follow-up surveys
  - Determining retention rates
  - What’s next time?

MUNICIPAL WATER DISTRICT OF ORANGE COUNTY

Questions?

Contact: Melissa Baum-Haley
Water Use Efficiency Programs Specialist
Municipal Water District of Orange County
714-593-5016
mbaum-haley@mwdoc.com

Document 2

ATTACHMENT 3 - PROJECT JUSTIFICATION

3.1 Project Summary Table

Table 4 – 2014 Drought Solicitation Project Summary

Drought Project Element		Interregional Landscape Water Demand Reduction Program
D.1	Provide immediate regional drought preparedness	X
D.2	Increase local water supply reliability and the delivery of safe drinking water	X
D.3	Assist water suppliers and regions to implement conservation programs and measures that are not locally cost effective	X
D.4	Reduce water quality conflicts or ecosystem conflicts created by the drought	X
IRWM Project Element		
IR.1	Water supply reliability, water conservation, and water use efficiency	X
IR.2	Stormwater capture, storage, cleanup, treatment, and management	
IR.3	Removal of invasive non-native species; creation and enhancement of wetlands; and acquisition, protection, and restoration of open space and watershed lands	
IR.4	Non-point source pollution reduction, management, and monitoring	X
IR.5	Groundwater recharge and management projects	
IR.6	Contaminant and salt removal through reclamation, desalting, and other treatment technologies and conveyance of reclaimed water for distribution to users	
IR.7	Water banking, exchange, reclamation, and improvement of water quality	
IR.8	Planning and implementation of multipurpose flood management programs	
IR.9	Watershed protection and management	X
IR.10	Drinking water treatment and distribution	
IR.11	Ecosystem and fisheries restoration and protection	

3.2 Project Description

3.2.1 Brief Description (25 words or less):

SAWPA-implemented interregional program for sustainable water-use conservation through a suite of measures: turf removal, technology-based information system, and conservation-based rate structures.

3.2.2 Implementing Agency/Organization

The Santa Ana Watershed Project Authority (SAWPA) is the applicant and will establish a process for implementation and expenditure of the grant funding.

SAWPA is composed of the funding partners Eastern Municipal Water District (EMWD), Inland Empire Utilities Agency (IEUA), Orange County Water District (OCWD), San Bernardino Valley Municipal Water District

(SBVMWD), and Western Municipal Water District (WMWD), which will assist with the Program's implementation.

SAWPA will collaborate with the Upper Santa Margarita Watershed (USMW) IRWM to assist with the implementation of the Program in their region.

3.2.3 How Project Will Address Drought Impacts, How It Is an Eligible Project Type, and Why Expedited Funding Is Needed (One page, min. 10 pt font):

This Program inherently includes the following eligibility attributes:

- Drought preparedness:
  - The Program is entirely a water conservation program.
  - The Program improves landscaping efficiencies by replacing turf with water efficient landscaping.
  - The Program achieves long term, permanent water conservation.
- Reliability of the local water supply will be increased by promotion of reasonable water use, reducing wasteful demands.
- The Program is not locally cost effective. Funding will be used to implement a conservation program that cannot be justified on financial characteristics alone; however, it is exceptionally beneficial for immediate and long-term conservation.
- The Program will reduce water quality conflicts by reducing poor-quality urban runoff, which contributes to polluting creeks and the ocean with fertilizers and pesticides.

Immediate and sustainable water conservation will be achieved by removing turf, providing feedback to customers with water budgets, performing retail customer comparison, and/or implementation of conservation-based rate structures. Aerial imagery is an integral component to all the Program tasks identified within this application. It is essential for locating turf, increasing accuracy of technology-based conservation, and as a foundation for water budget rates. These immediate conservation measures will reduce dependence on State Water Project (SWP) supplies, extraction from declining groundwater basins, and dependence on Colorado River supplies. Furthermore, this is a collaborative and interregional effort by agencies throughout the Santa Ana River Watershed and portions of the USMW, emphasizing the transformational, behavioral change in water use, including the following elements:

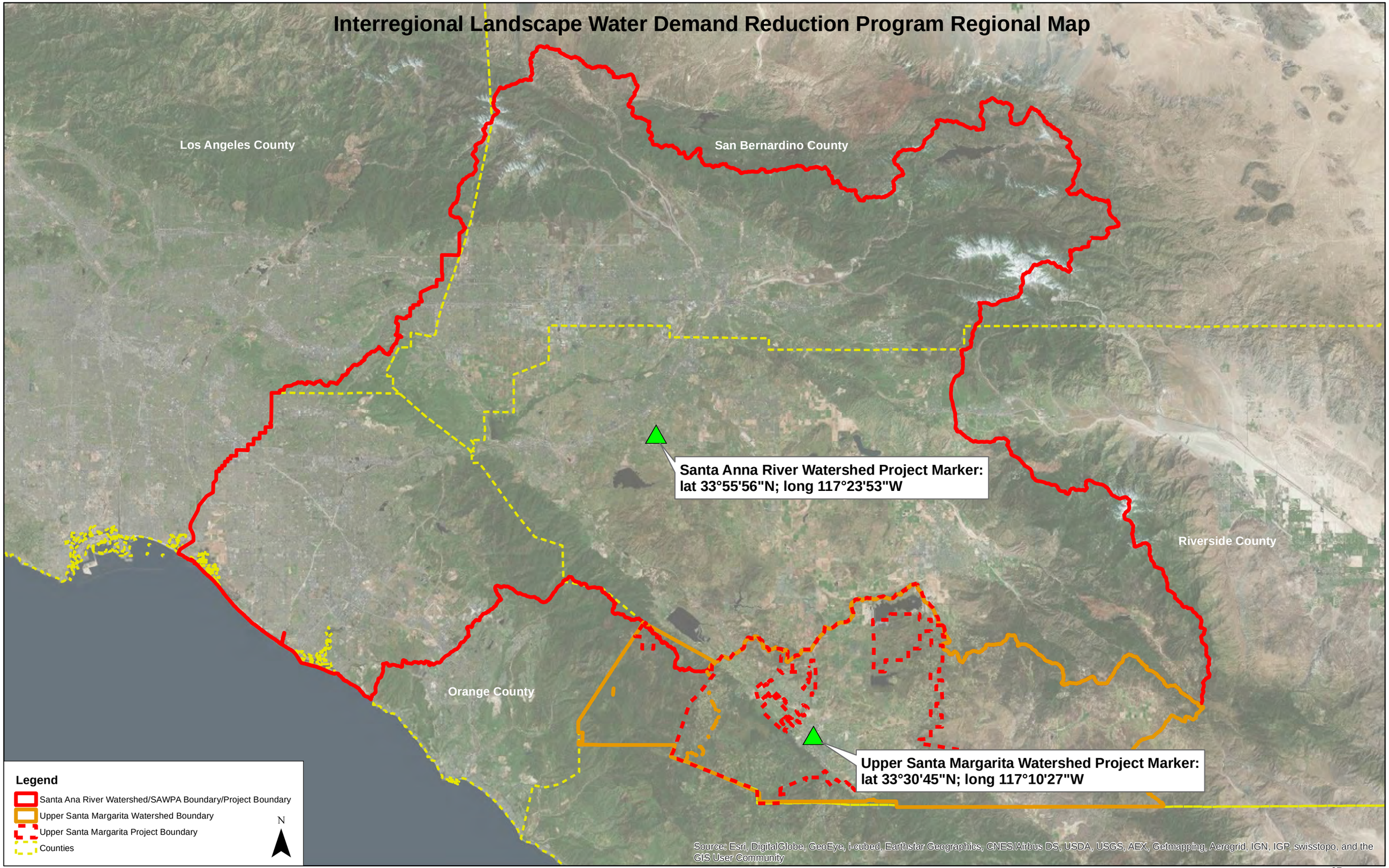
- ***Turf Removal.*** This element will integrate with local agencies' turf removal programs to target Commercial/ Institutional/Homeowners Association customers. Turf will be removed and replaced with more water-efficient landscaping, permanently reducing wasteful irrigation. "Funding Need" is justified because turf replacement is not locally cost effective, as cost savings do not outweigh the initial cost of replacement; however, water savings are significant. Additionally, turf irrigation is a significant contributor to poor-quality urban runoff, as it is typically overwatered and over fertilized. "Institutional" use includes schools, parks, etc.

- ***Technology-Based Information System.*** This element is an effective and rapid educational tool to change water use behavior. This system will transform the customers' view of the nexus between water's value and its reasonable use and result in permanent conservation. With more accurate landscape data provided through the aerial imaging measurement technology, data and outreach are significantly enhanced for accuracy to each customer. Should the drought persist, this can be a rapid updating tool for agencies to sort and rank accounts that waste water and provide feedback into the customer outreach campaign. "Funding Need" is due to the reduced budgets of agencies to expend funds during financially constrained times.

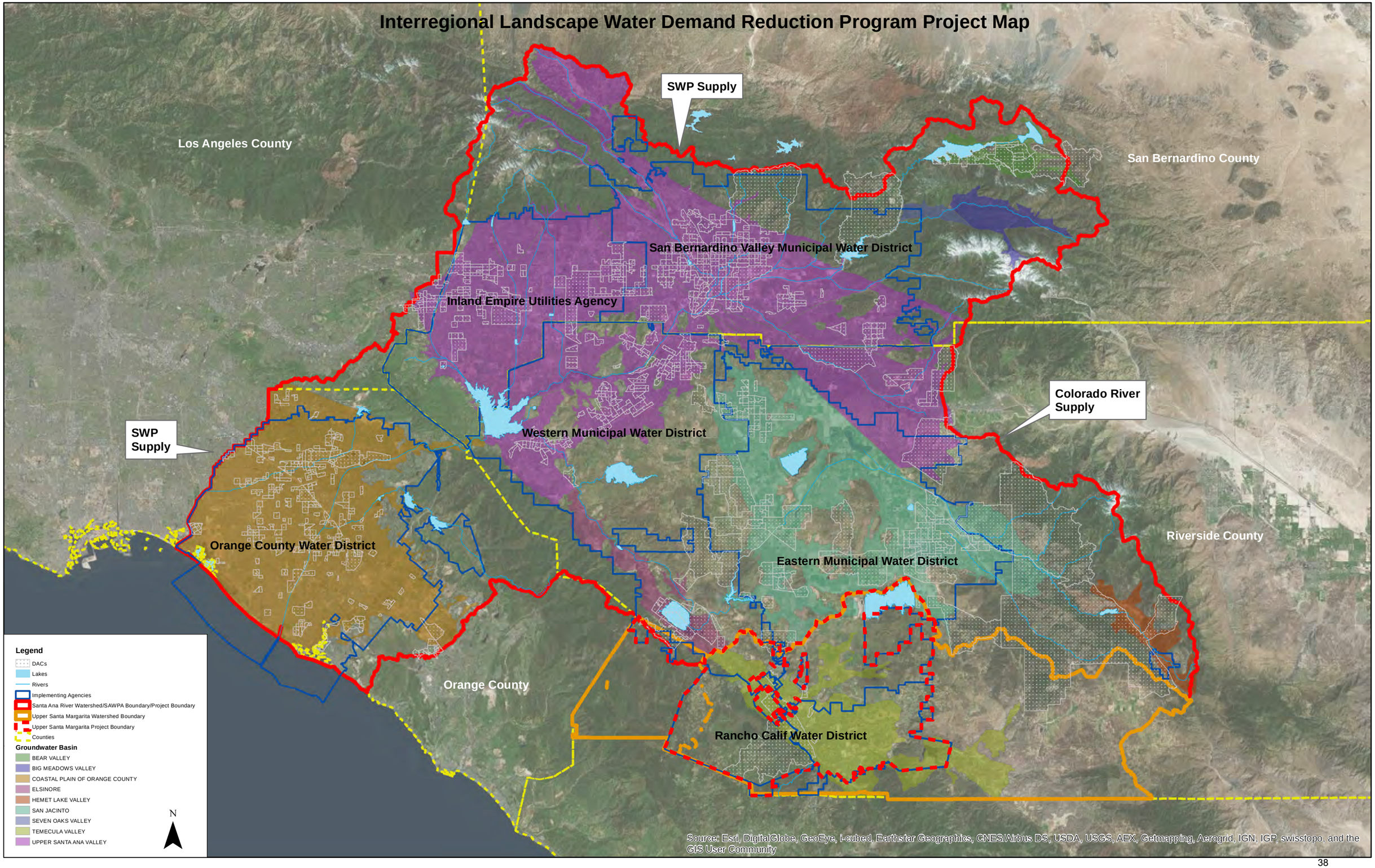
- ***Conservation-based Rate Structures.*** Early initiators of conservation-based rate structures have demonstrated significant water demand reduction, which assists in improving water supply reliability. Whether full implementation of budget-based rates or other conservation-based rates are used, this will provide steps toward transformational acceptance of rate structures' implementation to create permanent water conservation. This is a system change to permanently reduce water demands and the impacts noted above. "Funding Need" is due to the reduced budgets of agencies as noted above.

The adverse financial impact of the 6 years of recession coupled with the current drought have impacted water purveyors severely, greatly limiting their financial ability to implement new initiatives. The requested funding is needed to more effectively initiate more robust conservation programs that otherwise would not be implemented.

Interregional Landscape Water Demand Reduction Program Regional Map



Interregional Landscape Water Demand Reduction Program Project Map



3.3 Project Physical Benefits

Table 5. Annual Project Physical Benefits

Project Name: Interregional Landscape Water Demand Reduction Program
Type of Benefit Claimed: Water Supply Saved
Units of the Benefit Claimed: AF/year
Additional Information about this Benefit: N/A.

(a)	(b)	(c)	(d)
	PHYSICAL BENEFITS		
Year	Without Project	With Project	Change Resulting from Project (c) – (b)
2015	0	2,841	2,841
2016	0	5,945	5,945
2017	0	7,841	7,841
Etc.	0	7,841	7,841
Last Year of Project Life: 2037	0	7,841	7,841

Comments:

This water conservation program targets new water conservation and behavioral change; therefore, it is assumed that "Without Project" estimates are zero for presentation purposes.

Project Name: Interregional Landscape Water Demand Reduction Program
Type of Benefit Claimed: Energy Saved
Units of the Benefit Claimed: kWh
Additional Information about this Benefit: See comments for conversion of water saved to energy saved.

(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (c) – (b)
2015	0	6,961,248	6,961,248
2016	0	14,565,145	14,565,145
2017	0	19,209,385	19,209,385
Etc.	0	19,209,385	19,209,385
Last Year of Project Life: 2037	0	19,209,385	19,209,385

Comments:

According to the California Energy Commission's 2005 report California's Water-Energy Relationship, the amount of energy required to pump 1 AF to Southern California is on the order of 2,450 kilowatt-hours (average of East Branch and West Branch pumping to serve IEUA, Figure 2-2, pg 23).

Project Name: Interregional Landscape Water Demand Reduction Program
Type of Benefit Claimed: Carbon Emissions Saved
Units of the Benefit Claimed: MT CO_2
Additional Information about this Benefit: See comments for conversion of water saved to energy saved.

(a)	(b)	(c)	(d)
	Physical Benefits		
Year	Without Project	With Project	Change Resulting from Project (c) – (b)
2015	0	4,800	4,800
2016	0	10,043	10,043
2017	0	13,246	13,246
Etc.	0	13,246	13,246
Last Year of Project Life: 2037	0	13,246	13,246

Comments:

According to the US Environmental Protection Agency, the emission rate of CO_2 per kWh is 6.89551 × 10-4 metric tons CO2 per kWh (http://www.epa.gov/cleanenergy/energy-resources/refs.html)

3.4 Technical Analysis of Physical Benefits Claimed

The Interregional Landscape Water Demand Reduction Program (Program) is being proposed as a result of the 2014 statewide drought and future water supply reliability. The Program has four key physical benefits:

- Reduction of dependence on imported water supply (SWP and Colorado River supplies) (water supply savings);
- Energy savings;
- Reduction of carbon emissions; and
- Reduction of deleterious urban runoff water quality.

Savings in imported water supply is the primary physical benefit, with energy savings, carbon emissions savings and reduction of poor quality, urban runoff being secondary benefits. The Program will result in the implementation of water conservation tools and measures that will reduce the both the Santa Ana River Watershed's and USMW's need for imported water and improve water supply reliability. The savings in imported water supply lead to savings in energy and carbon emissions for the pumping and related facilities used to transport water to Southern California from the Bay–Delta via the California Aqueduct. Although approximately 60% of that energy used for conveying Bay–Delta supply is from hydroelectric power generation, it is assumed that reduction of this electrical demand will indirectly reduce reliance on fossil-fuel electrical generation.

3.4.1 Reduction of Imported Water Reliance

The Program will reduce water demands, and therefore reduce reliance on imported water, by over 7,841 AF/year by implementing turf removal, technology-based conservation outreach, and conservation-based water rates. This water conservation is critically needed, as the recent drought has caused elimination of the SWP as a supply source and significant reduction in groundwater recharge, resulting in severe depletion of groundwater storage and reduction of groundwater to critical levels as discussed in Attachment 2. The following elements of the Program will achieve these savings.

3.4.1.1 Turf Removal

Using estimates from data the Municipal Water District of Orange County (MWDOC) presented in 2013 (Reference: Baum-Haley, Melissa, *Get a CLWUE! The Comprehensive Landscape Water Use Efficiency Program* PowerPoint Presentation, MWDOC, October 3, 2013), we assume turf removal will provide a reduction in water demand of 44 gallons/SF of turf removal and replacement with less irrigation demanding landscape. For this element, the project will create the permanent reduction of 668 AF/year reliance on imported water (as presented in Table A, by removing approximately 4,950,000 SF of turf over a 3-year period.

Table A. Projected Turf Removal and Incremental Water Savings by Year

Year	Turf Removed in SAR Watershed (SF)	Turf Removed in USMW (SF)	Total Turf Removed (SF)	Water Savings[1] (gallons/SF removed)	Annual Water Savings (million gallons)	Annual Water Savings (AF/year)
1	2,000,000	500,000	2,500,000	44	110	338
2	1,300,000	400,000	1,700,000	44	75	230
3	700,000	50,000	750,000	44	33	101
Totals:	4,000,000	950,000	4,950,000	--	218	668

Notes:

[1] Value based on 2013 MWD presentation (Source: Baum-Haley, Melissa, *Get a CLWUE! The Comprehensive Landscape Water Use Efficiency Program* PowerPoint Presentation, MWDOC, October 3, 2013, slide #11 entitled "Turf Removal Rebate Program")

It is recognized that significant "unnecessary" turf exists as a legacy throughout the watersheds, and the drought and increased incentives to remove turf provides an opportunity to save more water immediately, particularly compared to other areas of California that receive more annual precipitation (i.e., turf removal in arid Southern California saves more water than the same turf removal in wetter areas of the State, all other things being equal).

MWD has reported that each incentive increase of their turf removal program has increased the participation by over 50% (MWD May 14, 2014 News Release, page 1). In May 2014, MWD further increased the rebate incentive from $1/SF to $2/SF and Santa Ana River Watershed and USMW water agencies have immediately seen a significant increase in residential applications, although only minor interest by non-residential customers, who could produce substantial water savings through this Program.

Overall, existing incentive programs for turf removal have resulted in participation heavily weighted by residential projects. MWDOC analysis of existing program data (actual cost accounting of turf removal and landscape replacement receipts) identifies that non-residential turf replacement projects are more costly ($6–$9/SF, $7.50/SF average) compared to residential projects at about $3/SF actual total cost. This is likely due to homeowners providing labor themselves in many cases and landscape designs with less planted density. MWDOC turf removal program participation over the last 4 years by non-residential customers was only 15% of participation; however, it averaged significantly higher square footage per project by a factor of 10, averaging removal of 11,700 SF/project compared to residential projects averaging 1,160 SF/project.

For this Program, the actual cost of removing 4,950,000 SF and replacing with lower water demand landscaping at an average $7.50/SF plus $883,333 for share of aerial imagery cost and $300,000 for implementation outreach cost, for a total of $38,308,333

This Program will integrate with MWD's and other local agency (such as MWDOC and WMWD; SBVMWD is planning to duplicate MWD's program in their service area) turf removal programs by targeting commercial/institutional/HOA large turf parcels with an additional $1/SF funding (total up to $3/SF, or approximately 40% of actual cost) to better incentivize implementation by non-residential parcels. Therefore, the program will emphasize non-residential customers to achieve additional water supply reduction in this land use classification not expected to participate in the lower incentive rebate program.

High resolution aerial images developed across the watersheds will provide the high-tech ability to locate high-turf percentage accounts to participate in turf removal rebate programs. This will enhance turf rebate effectiveness by identifying and directing outreach to the highest-yield customers. Landscape conversion is estimated to range from $6/SF to $9/SF. The program will enhance local funding from $2/SF to $3/SF for customers to remove 4,950,000 SF of turf.

This water conservation program targets new water conservation and behavioral change; therefore, it is assumed that "Without Project" estimates are zero for presentation purposes.

No new facilities or policies are needed to implement this element of the Program, nor are there any potential adverse physical effects due to turf replacement.

3.4.1.2 Technology-Based Information System

This element of the Program will result in estimated conservation and cumulative reduction of imported water need by 3,236 AF/year in 3 years (as presented in Table B) by reaching an estimated 150,600 customers with technology-based information systems. Note that assuming Program implementation will take 6 months, only one-half of the Year 3 value will be included in the total savings within the Program period.

Table B. Projected Water Use Reduction Due to Technology-Based Conservation by Year

Year	Savings Rate[1,2]	Usage/Customer[3] (AF/year)	Number of Customers[4]	Annual Water Savings[5] (AF/year)
1	5%	0.665	150,600	5,007
2	3%	0.632	150,600	2,855
3	2%	0.613	150,600	1,846
Total Average Year 3 Projected Savings (AF/year)				3,236

Notes:

[1] Year 1 savings based on findings at EBMUD for implementation of WaterSmart Software (Source: Mitchell, D. and Chesnutt, T. *Evaluation of East Bay Municipal Utility District's Pilot of WaterSmart Home Water Reports*. California Water Foundation and East Bay Municipal Utility District. December 2013, specific pages iv, 34, 56 and 60.) Year 1 savings coincides with the last 6 months of 2015 and first 6 months of 2016 (assumes 6 months to implement).

[2] Year 2 and 3 savings based on findings from longer-term persistence analysis of behavioral nudges (Source: Bernedo, M., Ferraro, P. and Price, M. *The Persistent Impacts of Norm-based Messaging and their Implications for Water Conservation*. Journal of Consumer Policy, Table 3 page 10.) Savings are on top of previous year. Year 2 savings coincide with July 2016-June 2017. Year 3 savings occur July 2017 to Dec 2017 (6 months only).

[3] Annual average household water usage calculated for Year 1 based on 180 gpd/capita (Source: http://www.sawpa.org/wp-content/uploads/2014/01/8-Per-Capita-Water-Use.pdf) and assuming 3.3 persons/EDU. Subsequent years' usage reduced by the savings rates listed in column two.

[4] Of the total number of customers, 600 are in the USMW. The remaining 150,000 are in the Santa Ana River Watershed

[5] Year 3 water savings reported for project will only occur for last 6 months of 2017; therefore, only half of this value will be used in the water savings benefits (see Table 5).

The Technology-Based Information System tool will be an effective and rapid educational tool to use to immediately obtain water conservation. With accurate landscape area data provided through the aerial imaging/square footage measurement technology, the data and outreach are significantly enhanced for accuracy to each customer. In addition, should the drought persist, the water efficiency calculator mentioned above can be a rapid updating tool for agencies to sort and rank accounts that waste water and feed back into the Technology-Based Conservation customer outreach campaign. Implementation of this approach may include agency development of the tool, a collaborative approach between agencies to develop the tool, or third-party vendors such as WaterSmart.

For the Program, we are conservatively basing our analysis on the application of 1 year's funding of the Technology-based Conservation outreach, and include the documented water conservation effects over a 3-year duration. This approach intends to obtain water savings and demonstrate the potential savings to water purveyors. Ultimately, this will provide agencies the ability to document the water savings success both individually and watershed-wide to support whether continued funding locally after Year 1 is cost effective.

Continuation or Durability effects (i.e., the ongoing effect if the reports continue over time, past 1 year) as opposed to the Persistence effects (i.e., the effect if the reports stop) have been studied for this new approach. These studies indicate that reasonable expectation of water savings include 5% in the first year, 3% in the second year, and 2% in the third year if the reports are only provided for the first year (therefore, the conservation effect declines in subsequent years) (References: Results showing 5% for EBMUD: Mitchell, D. and T. Chesnutt, *Evaluation of East Bay Municipal Utility District's Pilot of WaterSmart Home Water Reports*, California Water Foundation and East Bay Municipal Utility District, December 2013, specific pages iv, 34, 56 and 60; Results showing persistence of one time message: Bernedo, M., P. Ferraro, and M. Price, "The Persistent Impacts of Norm-Based Messaging and Their Implications for Water Conservation," *Journal of Consumer Policy*, May 25, 2014, Table 3, page 10). It should be noted that the Continuation or Durability effects of continued use illustrate increased savings.

Actual local cost for participation of 150,600 customers is $1,504,950 plus $883,333 for share of aerial imagery cost and $248,160 for implementation outreach cost, for a total of $2,636,443/year.

No new facilities or policies are needed to implement this element of the Program, nor are there any potential adverse physical effects due to turf replacement.

3.4.1.3 Conservation-Based Water Rates

Conservation-based water rates influence and can reduce any and all water use, particularly wasted water. Using the state efficiency standards, this task can help agencies meet long-term conservation legislation and hold water efficiency gains during drought restriction times.

Per Proposition 26 and 218, water rates must be structured based on "cost of service." While this requirement may somewhat hinder utilizing higher prices to incentivize water use reduction, water rates can be developed meeting these requirements while also providing a level of conservation. Water rates can be developed in creative structures that accurately fund fixed costs, variable costs, differing water supplies' costs, and water conservation programs while also financially conveying to the rate payers the value of their individual water use. Some forms of conservation rate programs can also provide a new "local" funding source for conservation, enabling local agencies to conduct more aggressive conservation efforts in the future.

Conservation-based rate structures have, when fully implemented, resulted in sustained water demand reduction of up to 17% for budget-based rates (University of California, Riverside/Baerenklau et al. study "Residential Water Demand Effect of Increasing Block Rate Water Budgets", specific page #1). Other approaches to conservation-based rate structures may also provide lower water savings by providing the initial steps of a transformational rate structure. For these other approaches, a water savings of 5% will be assumed in the initial 3-year project implementation, with anticipated increasing water savings subsequently into the future.

Implementation of this Program will include educating policy makers on the effectiveness of conservation-based rate structures, creating outdoor water budgets, consulting, and developing rate structures for conservation-based rates. The Program would outline procedures, software, training, and outreach necessary to cost-effectively implement a program in their agency. There are 73 water purveyors in the Santa Ana River Watershed that do not have a water budget by connection (the three agencies in the USMW participating in the Program each have budget-based rate structures), of which we estimate up to 30 would be interested in developing outdoor water budgets, up to 20 interested in preparation of a cost/benefit analysis of conservation rate structure, and finally, up to 10 water agencies committing to implementation of conservation-based water rates that provide a pricing mechanism to alter behavior. Assuming a resulting minimum 5% reduction in water use (different rate structures

will have varying effectiveness on conservation) for a targeted 10 agencies with an average of 14,500 customers, average annual water demand will decrease by approximately 4,800 AF/year in 3 years, as shown in Table C.

Table C. Projected Water Savings from Conservation-Based Rates by Year

Year	No. Agencies Implementing[1]	Usage/Customer[2] (AF/year)	Reduction in Water Use[3]	Annual Water Savings (AF/year)
1	0	0.665	5%	0
2	3	0.665	5%	1446
3	7 additional	0.665	5%	3375
			Total 3 Year Projected Savings (AF/year)	4,821

Notes:

[1] Per Raftelis Financial estimate given their experience in the region, 30 agencies will explore converting to conservation based rates and 10 of those will actually convert. Anticipated that explorative period will take about 1 year, with the first three agencies completing implementation in Year 2 and the remaining in Year 3. Assumes each agency has 14,500 connections, which is median value of SAWPA retail agencies being targeted. USMW agencies are not participating in this element as they have already implemented conservation-based rates.

[2] Annual average household water usage calculated for Year 1 based on 180 GPCD (Source: http://www.sawpa.org/wp-content/uploads/2014/01/8-Per-Capita-Water-Use.pdf) and assuming 3.3 persons/EDU.

[3] Estimated water savings rates range from 5 to 17%. For the purposes of this analysis, we are using the most conservative estimate of 5% (Source: Raftelis Financial).

The implementation cost of soliciting and implementing water conservation-based rates for 10 agencies, including $833,333 for aerial imagery and $200,000 for outreach coordination, is estimated to be $3,165,333

The Conservation-Based Water Rate element of the Program will be implemented in the following approach:

1. Workshops – To create initial momentum of interest, four workshops in each of the three counties of the Santa Ana River Watershed (total of 12 workshops) will be held targeting the 73 water purveyors. Workshops would be tailored to both elected officials and staff members. These workshops will review various factors to determine outdoor water budgets, conservation-based rate structures, billing system requirements, and other general issues that would need to be addressed in implementing conservation-based water rates. These workshops are intended to educate and elicit interest in these rate structures.
2. Outdoor Water Budget Development – Up to 30 water purveyors will be targeted from interest expressed at the workshops or other communication to develop outdoor water budgets. The outdoor water budgets are the amount of water a parcel needs to maintain a healthy landscape. This budget would be calculated for each parcel using aerial mapping and local weather conditions. Based on this information, water agencies can compare actual usage with the water budget to determine which accounts are efficient or wasteful with their water use. The information can then be used to target water conservation programs, which would complement other programs within the Program and can educate individual accounts on how efficiently they use water.
3. Cost/Benefit Analysis of Conservation Rate Structure – Based on the Outdoor Water Budget study, the benefit from reducing wasteful water and the cost of implementing conservation rate structures will be determined for up to 20 water purveyors. The benefits that will be examined include the avoided cost of purchased water, lower Capital Improvement Program expenditures and increased watershed quality from lower urban runoff. The cost of the conservation structure will include billing system assessment, potential increase in staff, and public outreach.
4. Conservation Rate Pricing – From the Outdoor Water Efficiency and Cost/Benefit Analysis studies above, up to 10 water purveyors committing to implement conservation-based rates will be provided further study and development of customized conservation-based rate structures, consistent with requirements of Propositions 26 and 218, for implementation. Pricing would be the main tool in this element of the program to transform customers' view of the nexus between the value of water and its reasonable use.

This analysis will also take into account revenue shortfall so that as the agency reduces demand, the financial condition of the utility is not jeopardized. These water purveyors are targeted for implementation of the rate structures.

No new facilities or policies are needed to implement this element of the Program, nor are there any potential adverse physical effects due to implementation of water conservation-based rates.

3.4.1.4 Supporting Water Use Efficiency Tools

Economies of scale will be utilized to provide tools that will be used in the implementation of the Program elements described above as well as other uses by water agencies in the water use efficiency programs. While these tools are integral to the implementation of the Program described herein and water savings are presented, it should be noted that these tools will facilitate unquantified water use savings with these other, unidentified uses.

Aerial Imagery – High resolution aerial imagery at six inches/pixel resolution, including infrared and Lidar, will be produced for the urbanized area of the Santa Ana River Watershed and portions of the USMW and provided to all water purveyors. Economies of scale will reduce the cost of this mapping, and also provide this tool to water agencies that might not otherwise utilize this technology due to cost. This high resolution remote sensing information with measurement of irrigated area and percentage of turf grass will be provided for both residential customers and for commercial sites in the watersheds. The aerial images developed across the watersheds will provide agencies the ability to locate high-turf-percentage accounts to target for local agency outreach to participate in turf removal rebate programs. This will return more savings by identifying and directing outreach to the highest-using customers. This imagery and modeling will also provide cost-effective information to be used in the Technology-Based Information Outreach and Conservation-Based Water Rate Structure implementation. Aerial imagery will have multiple uses as a basis for both short-term and long-term water savings for this Program.

Implementation of Watershed Coordination – To maximize the financial resources among the participating agencies, the coordination and outreach throughout the watersheds needs to be regional and robust. The challenge will be to connect the public, and all stakeholder audiences, to direct calls to action that encourage significant behavior change.

Initial implementation steps will include an analysis of existing data and a newly generated survey to test attitudes, knowledge and appetite for change in water use. This information, along with extensive assessments of existing agency outreach efforts and materials and evaluation of regional earned media, advertising, event, and partnership landscape, will lead to the development of a comprehensive regional outreach plan.

The survey data and market analysis will assist in identifying key messages, campaign brand elements, and targeting methodologies for outreach plan implementation. Primary focus areas for implementation include comprehensive message development, branding and campaign launch design, sophisticated and interactive web platform development, earned and social media engagement, advertising, sponsorship and strategic partnership development, and special event planning. Further, all elements will include provisions for customizable campaign elements, budgeting detail, and specialized spokesperson training for both individual staff and elected leaders at each agency.

3.4.2 Water Savings Summary

Projected water savings are summarized in Table D.

Table D. Projected Water Supply Savings Benefit by Year

Year	Turf Replacement	Tech-Based Information System	Conservation-Based Water Rates	Totals (AF/year)
2015	338	2,504	0	2,841
2016	567	3,931	1,446	5,945
2017	668	2,351	4,821	7,841

Notes:
Note that Year 1 of the Tech-Based Conservation Program from Table B occurs from July 2015 to June 2016, Year 2 from July 2016 to June 2017 and Year 3 from July 2017 to December 2017. Hence the values on Table B were input here accordingly.

3.4.3 Energy Saved

According to the California Energy Commission's 2005 report California's Water-Energy Relationship, the amount of energy required to pump 1 AF to Southern California is approximately 2,450 kilowatt-hours (kWh) (average of East Branch and West Branch pumping to serve IEUA, Figure 2-2). This results in savings of 6,964,248 kWh in 2015, 14,564,145 kWh in 2016, and 19,209,385 kWh in 2017 through 2037 (20-year project life).

3.4.4 Carbon Emissions Saved

According to the U.S. Environmental Protection Agency, the emission rate of carbon dioxide (CO_2) per kWh is 6.89551×10^{-4} metric tons CO_2 per kWh (http://www.epa.gov/cleanenergy/energy-resources/refs.html). Using this conversion rate, the amount of carbon emissions saved with the program are: 4,800 MH CO_2 in 2015, 10,043 MT CO_2 in 2016, and 13,246 MT CO_2 in 2017 through 2037 (20-year project life).

3.4.5 Water Quality – Reduction of Urban Runoff

Recent Salt and Nutrient Management Plans have demonstrated that the highest contributor to TDS loading is from turfgrass return flows (Rancho California Water District, Temecula Valley Basin Salt and Nutrient Management Plan, March 2014). Permanent water conservation produced from the program will result from the reduction in turfgrass overwatering, which creates the majority of urban runoff. Over fertilization, pet waste, pesticides, etc. get carried along with this overwater into the urban runoff tributary to creeks, the groundwater basins, and the ocean. Removing turf and incentivizing effective reduction of outside irrigation will reduce this runoff and improve water quality in creeks, in groundwater, and at the beaches, benefiting human health and welfare as well as wildlife.

3.5 Cost-Effectiveness Analysis

The proposed program is the least cost alternative (see Table 6, Cost Effective Analysis), and can be immediately implemented to mitigate drought reduction of water supply with water savings commencing in the first year and fully implemented with 7,841 AF/year water savings within 3 years. Comparable alternatives, to create new water supply as opposed to reducing demand, include recycled water expansion where implementation would be 5–10 years, and ocean desalination, which would not be implemented for over 10 years, if at all, depending on environmental and cost limitations.

Table 6 – Cost Effective Analysis

Project Name: Interregional Landscape Water Demand Reduction Program	
Question 1	Types of benefits shown in Table 5 include: 7,841 AF/year of Imported Water Supply Saved, 19,209,385 kWh Energy Saved and 13,246 MT CO_2 Carbon Emissions Saved for 20 years.
Question 2	Yes, alternative methods have been considered for achieving the same types and amounts of physical benefits as the proposed project, including expansion of recycled water facilities throughout the region and ocean desalination. These alternatives are new sources of supply that would also offset reliance on imported water. The following are the estimated costs of the Subject Project compared to the alternatives: • Interregional Landscape Water Demand Reduction Program (Subject Project): $254/AF ($22.9M, 7,841 AF/year, (A/P, 6%, 20)=0.0872) • Recycled water development: $887/AF (reference: *http://www.gwrsystem.com/index.php?option=com_content&view=article&id=9&Itemid=27* for OCWD GWRS project costs) • Ocean Desalination: $2,014/AF (reference: *http://www.sdcwa.org/seawater-desalination* for SDCWA Carlsbad Ocean Desal Plant)
Question 3	The proposed program project is the least cost alternative.
Comments: The proposed program is the least cost alternative, in addition can be immediately implemented to mitigate drought reduction of water supply with water savings commencing in the first year and fully implemented in 3 years. Recycled water expansion implementation would be 5–10 years, with Ocean Desalination >10 years, if at all, depending on environmental and cost limitations.	

Document 3

My Water Savings

We're for Water

By replacing your current fixtures with the WaterSense labeled fixtures you selected, you'd save...

Water:

3,600 gallons saved annually
Equivalent to washing 88 loads worth of laundry

Natural Gas:

2,300 cubic feet annually
Equivalent to heating your house for 6 days

Greenhouse Gas Emissions:

250 pounds of greenhouse gas emissions annually
Equivalent to taking 1 car off of the road for 8 days

Money:

$55.00 in utility bills annually

Recalculate How Much I'll Save

Recalculate your results by clicking the link above and changing the information you provide.

Ready To Save?

- ► **Find** a WaterSense labeled product
- ► **Discover** more ways to save
- ► **Pledge** to save water

Tell your friends about your savings

Like

» How it works
» MS Excel version

Document 4

Orange County & Riverside County Energy Saving Retrofit									
Unit	Quantity per Home	No. of Homes	Annual kWh saved per Home	Annual Therms saved per Home	Project Annual kWh	Project Annual Therm	Total Annual Project kWh (Therm & KWH)**	Expected Useful Life (Years)	Explanation on Expected Useful Life
Level 1 Efficiency Measures (Installed by Outreach Field Personnel)									
LEDs (60W equivalent)*	12	1,600	657	-	1,051,200	-	1,051,200	23	See supporting documentation.
Low-flow Showerheads (1.5 GPM)*	2	1,600	-	70	-	112,000	3,281,600	10	See supporting documentation.
Thermostatic Shower Shut-off Valves*	2	1,600	-	38	-	60,800	1,781,440	10	Assumed useful life.
Adjust Water Heater Temp*	1	1,600	-	13	-	21,408	627,254	10	Assume benefits are realized for half of 20-year water heater useful life.
Secondary Fridge Removal*	1	104	1,285	-	133,640	-	133,640	8	Assume benefits are realized for half of 16.6-year fridge useful life.
Overall Total/Average	**18**	**160**	**1,942**	**121**	**1,184,840**	**194,208**	**6,875,134**		
Subtotal W/Fridge	n/a	n/a	1,285	n/a	133,640	n/a	133,640	**12**	Weighted average of useful life of all measures.
Subtotal W/Out Fridge	n/a	n/a	657	121	1,051,200	194,208	1,245,408		

*See supporting document.

**Therm to kWh conversion done through Center Point Energy - see supporting document.

Savings Estimate for ENERGY STAR Qualified Light Bulbs

LEARN MORE AT energystar.gov

Results Overview

The ENERGY STAR models of your selected light bulbs will save approximately 83%. Each year you will save approximately 657 kWh of electricity and $102. Over the life of the light bulbs you will save approximately $1,511 in electricity costs and $75 in equipment replacement costs. By choosing ENERGY STAR you will reduce emissions by approximately 1,012 pounds of carbon dioxide annually, which is equivalent to the emissions reduction of not driving your car for 35 days.

Results Detail

	Quantity	Annual Total					Life Cycle Total				% Electricity Savings with ENERGY STAR	Total additional purchase price	Simple payback period for additional initial cost (years)	Assumed equipment lifetime (years)
		Electricity cost savings	Electricity savings (kWh)	Electricity cost	Electricity consumption (kWh)	Emissions reduction (pounds of CO2)	Electricity cost savings	Electricity savings (kWh)	Avoided cost for replacement bulbs & labor	Net cost savings				
CFL														
	0													
LED omnidirectional														
Bulb 1 (10 W LED replacing 60 W)	12	$102	657	$20	131	1,012	$1,511	15,000	$75	$1,470	83%	$115.20	1.1	22.8
	0													
	0													
	0													
Total	12	$102	657	$20	131	1,012	$1,511	15,000	$75	$1,470	83%	$115	1.1	-

Notes: Savings for ENERGY STAR lighting includes an avoided cost for replacements because efficient lighting typically lasts longer than conventional lighting.
More efficient lighting releases less heat into the surroundings, so upgrading to ENERGY STAR lighting may also have an impact on your heating and cooling costs.
Total additional purchase price is the incremental cost for ENERGY STAR equipment reduced by any rebate/incentive amount entered on Inputs tab.
Life cycle cost savings are given in terms of present value based on a real discount rate of 4%. See General Assumptions tab to adjust the discount rate.
Life cycle net cost savings = life cycle electricity cost savings + avoided replacement cost - additional purchase price
Simple payback calculation is based on total additional purchase price, annual electricity cost savings and annual bulb replacement costs

If every American home replaced their 5 most frequently used light fixtures or the bulbs in them with ones that have earned the ENERGY STAR, we would save approximately $8 billion each year in energy costs, and together we would prevent the greenhouse gases equivalent to the emissions from 10 million cars.

This calculator was developed by U.S. EPA and DOE to estimate the energy consumption and operating costs of light bulbs and the savings with ENERGY STAR.
New ENERGY STAR qualified light bulbs are compared to the average available new conventional light bulbs. Actual savings may vary based on use and other factors.
See www.energystar.gov for information on other ENERGY STAR products.

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Soft White

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Lighting Facts on Cree LED Bulb package

Lighting Facts
Per Bulb

Brightness	815 lumens
Estimated Yearly Energy Cost Based on 3 hrs/day, 11c/kWh. Cost is based on rates and use	$1.32
Life Based on 3 hrs/day	22.8 years
Light Appearance Warm — Cool 2700 K	
Energy Used	11 watts

Additional Photos

Low-flow Showerheads (1.5 GPM) – Detailed Energy Savings		
Data Point	Quantity	Source
Average number of people per household	4	http://www.city-data.com/city/Santa-Ana-California.html http://www.city-data.com/city/Jurupa-California.html
Average number of showers/person/day	0.67	http://www.epa.gov/WaterSense/docs/showerheads_finalsuppstat508.pdf
Days/year	365	
Average shower duration (minutes)	8.2	http://www.epa.gov/WaterSense/docs/showerheads_finalsuppstat508.pdf
Showering minutes/houshold/year	8,021	8021.24
GPM of existing showerheads	2.5	
GPM of new showerheads	1.5	
GPM saved	1	
Gallons saved/household/year from low-flow showerheads	8,021	=8,021*1
Specific heat of water = 1.0BTU/lb x degree F	1	
BTUs/Therm	99,976	
Pounds/gallon of water	8.34	
Average temperature of water in pipes	67	
Average temperature of heated water	130	Most water heater manufacturers set the thermostat to 140: http://energy.gov/energysaver/projects/savings-project-lower-water-heating-temperature. Assume average existing temperature is 130.
Delta T	63	Water heater must raise the temperature of the water from 67 degrees to 130 degrees
Energy efficiency	0.6	http://www.epa.gov/WaterSense/docs/showerheads_finalsuppstat508.pdf
Therms/gallon heated	0.00876	= (1.0BTU/lb*degree F)*(1 Therm/99.976 BTU)*(8.34 lbs/1 gallon)*(67 degrees F)/0.60
Therms saved/household/year from low-flow showerheads	**70.26**	**= 0.00876*8,021**

Thermostatic Shower Shut-off Valve - Detailed Energy Savings		
Data Point	Quantity	Source
Therms used/household/year from showering	92.01	=0.0076*12,032
Therms wasted/household/year without thermostatic shut-off vavle	37.72	37.7241 In a Lawrence Berkeley National Laboratory study, 41% of hot water energy was wasted while waiting for water to heat up: http://eetd.lbl.gov/sites/all/files/water_and_energy_wasted_during_residential_shower_events_findings_from_a_pilot_field_study_of_hot_
Therms saved/household/year with thermostatic shut-off valve	**37.72**	**Calculation**

* Slight variations in the results of equations are due to rounding.

See Page 25 for Showerhead Expected Useful Life

Low Flow Showerheads As A Regional Energy Savings Measure

Submitted To:

Bonneville Power Administration

February 2, 2010

SUMMIT BLUE CONSULTING, LLC

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1 INTRODUCTION

Low-flow showerheads offer the potential to save water and energy used to heat water by reducing the amount of hot water and the total amount of water consumed for showering. In the U.S., federal mandates limit new showerheads to a maximum flow rate 2.5 gallon per minute (gpm)[1]. While the majority of showerhead market share is comprised of showerheads rated at 2.5 gpm, low-flow models are available that are rated at 2.0, 1.75, 1.5, and even 1.0 gpm. However, as examined in this report, determined savings is more complicated than simply comparing flow-rates. This report examines the energy savings and cost-effectiveness associated with showerhead retrofits for the BPA service territory.

The Regional Technical Forum (RTF) has previously approved a deemed savings for 2.0 gpm residential showerheads. This report reexamines these savings, considers savings from residential showerheads rated at less than 2.0 gpm, and considers low flow showerheads for select commercial applications.

While low-flow showerheads are widely promoted, energy and water savings from low-flow showerheads are not well understood, especially for showerheads rated at less than 2.0 gpm. Uncertainties include:

- **Shower duration -** the effect of shower flow rate (and other performance factors) on shower duration. *Appendix A: Shower Duration* examines this issue.
- **Shower temperature -** the effect of shower flow rate (and other performance factors) on shower setpoint temperature. This is addressed in Section 3.2.1.
- **Product satisfaction** – the effect of factors such as flow rate, other showerhead performance factors, plumbing system pressure, individual's hair length on product satisfaction. *Appendix B: User Satisfaction* examines this issue.
- **Baseline commercial consumption** – public research has not been conducted on even the *baseline* commercial sector shower water and energy use. Section 3.1.2 describes the commercial baseline assumptions used in this analysis.
- **Measure persistence** – the effective useful life of low-flow showerheads, affected by prevalence of showerhead tampering, showerhead removal, showerhead failure. This is discussed in Section 4.3.
- **Risk of scalding and thermal shock** – modern one-handle showers contain a pressure balancing and/or temperature balancing features intended to reduce the risk of sudden temperature swings. These devices are not necessarily designed to operate at lower flow rates. *Appendix C: Scalding and Thermal Shock Risk* examines this issue.

The remaining sections of the report examine the water and energy savings from retrofitting existing showers (Section **Error! Reference source not found.**) and the cost, lifetime, and cost effectiveness of these measures (Section 4). Definitive research on the topics discussed in this report do not exist; Section 6 describes key areas for further research. Including the measures proposed in this report to conservation programs would be a useful starting point for generating the field data necessary to reach more definitive conclusions on these topics. XXX NEED TO UPDATE TO FINAL REPORT STRUCTURE

[1] The Federal Energy Policy Act of 1992 restricts flow to 2.5 gpm at 80 psi gage pressure.

2 MEASURE SPECIFICATION

This report reviews savings estimates for low-flow showerheads rated at 2.0 gpm or below for both residential and commercial applications. The targeted customers for this measure are those with existing showerheads, which, on average, are rated at approximately 2.5 gpm. Measures are specified for residential and select commercial applications, and for both gas and electric water heating.

2.1.1 Residential Measure Specification

For the residential measure, three flow rates (1.5 gpm, 1.75 gpm, 2.0 gpm), three water heat types (electric, gas, any), and three shower types (primary, secondary, any) are specified and allowed in any combination. This results in 27 unique measures. Table 1 summarizes the residential showerhead measure categorization.

Table 1. Residential Showerhead Measure Categorization

Sector	Residential
Category	Water Heating
Subcategory	Showerheads and Faucets
Technology, Measure or Practice	Low-flow Showerhead, {1.5 gpm, 1.75 gpm, 2.0 gpm}
Unit Type	Showerhead
Building Type	All Residential Dwelling Types
Vintage	New and Existing Construction
Other 1	{Electric Resistance Water Heater, Gas Water Heater, Any Water Heater}
Other 2	{Primary Showerhead, Secondary Showerhead, Any Showerhead}
Delivery Mechanism or Program	
ID_Mechanism	
Application	Residential Water Heating
ID_Application	
Lost Opportunity?	Yes - many customers would otherwise purchase 2.5 gpm showerheads
Location	Regionwide
ID_ClimateZone	

In addition, the following specification of measure eligibility from the current residential showerhead measure should be retained, with the modification of the flow rate to describe the three flow-rates specified:

> "Replacement showerhead shall be pressure-compensating with non-removable flow controller and have flow rate of *[FLOW RATE]** or less as tested at 80 psi (552 kPa) in accordance with ANSI standard A112.18.1M. Showerhead shall be installed by utility staff or utility contractor or delivered to the consumers in fulfillment of their request. Limited to two (2) showerheads per residence."

**The actual text of this would be either 1.5 gpm, 1.75 gpm, or 2.0 gpm, depending on the measure.*

2.1.2 Commercial Measure Categorization

The commercial measure categorization is similar to the residential specification, with two exceptions: several different building types are specified (hospitality, health care, and small commercial employee shower) and all affected showers will be considered primary showers. Table 2summarizes the residential showerhead measure categorization.

Table 2. Commercial Showerhead Measure Categorization

Sector	Commercial
Category	Equipment
Subcategory	Showerheads and Faucets
Technology, Measure or Practice	Low-flow Showerhead, {1.5 gpm, 1.75 gpm, 2.0 gpm}
Unit Type	Showerhead
Building Type	{Hospitality, In-patient health care and assisted living, Employee shower}
Vintage	New and Existing Construction
Other 1	{Electric Resistance Water Heater, Gas Water Heater, Any Water Heater}
Other 2	All
Delivery Mechanism or Program	
ID_Mechanism	
Application	Commercial Water Heating
ID_Application	
Lost Opportunity?	Yes - many customers would otherwise purchase 2.5 gpm showerheads
Location	Regionwide
ID_ClimateZone	

In addition, the following specification of measure eligibility from the current residential measure should be retained, with the modification of the flow rate to describe the three flow-rates specified and the removal of the two showerhead per residence limit.

> "Replacement showerhead shall be pressure-compensating with non-removable flow controller and have flow rate of *[FLOW RATE]** or less as tested at 80 psi (552 kPa) in accordance with ANSI standard A112.18.1M. Showerhead shall be installed by utility staff or utility contractor or delivered to the consumers in fulfillment of their request."

**The actual text of this would be either 1.5 gpm, 1.75 gpm, or 2.0 gpm, depending on the measure.*

2.2 Water and Energy Savings Estimation Approach

Savings from an adjustment to shower conditions and/or behavior can be determined by determining the pre- and post-retrofit shower water and energy consumption. The consumption of water for showering can be computed as the product of the following parameters:

- Daily showers per Person (showers per person per day)
- *Annualized Occupancy (days per year)
- *Persons per Showerhead (people per showerhead)
- Shower Flow Rate (gpm)
- Average Shower Length (min per shower)

Parameters with an asterisk (*) before them are assumed to be constant across the pre- and post-retrofit cases.

The consumption of energy for showering (on an annual basis) can then be computed as the product of the following parameters:

- Annual water consumption (gallons/year)
- Shower Water from Hot Tap (%)
- *Water heater outlet temperature minus inlet temperature (°F)
- *Water Heater Heating Energy (kWh per °F per gallon)

Parameters with an asterisk (*) before them are assumed to be constant across the pre- and post-retrofit cases.

The approach used in this analysis to estimating gross savings from showerhead retrofits is to subtract the post-retrofit showerhead consumption from the pre-retrofit consumption. Gross savings are then scaled down to account for participants who do not install the showerhead they receive, tamper with the showerhead to increase the flow rate[2], or remove the showerhead soon after installing it. Further factors affecting true net energy savings, such as free-ridership and spill-over, are not addressed in this analysis.

[2] Note that this is minimized by specifying showerheads with non-removable flow regulators as part of the measure specification.

3 BASELINE AND POST-RETROFIT PERFORMANCE AND USAGE ASSUMPTIONS

3.1 Baseline

Low-flow showerheads replace existing showerheads that may be pre-1992 showerheads capable of 3 to 5 gpm, EPAct 1992 qualifying 2.5 gpm showerheads, or may be low-flow showerheads rated at less than 2.5 gpm. This analysis considers both sites with electric water heating and with gas water heating.

3.1.1 Residential Baseline

Much of the baseline specification used for this report is that used in the RTF's current residential showerhead deemed savings measure. The research conducted to determine these values is recent (2006), regionally relevant (conducted in Seattle), and contained a large sample size (71 homes) relative to other showerhead retrofit studies. Each of the parameters used in the baseline energy calculation are discussed below. The same baseline is used for each of the three retrofit flow rates (2.0, 1.75, and 1.5 gpm).

- **Daily showers per Person (showers per person per day)** – From the 2007 analysis, 0.55 for primary showerheads in households, 0.28 for secondary showerheads (and assuming 33% of households have a second showerhead). This implies a total of 0.64 showers per person. These values do not significantly conflict with any of the other studies reviewed, and are retained for this updated analysis.

- **Annualized Occupancy (days per year) –** The 2007 analysis assumed 350 days per year. This value is reasonable and is retained for this updated analysis.

- **Persons per Showerhead (people per showerhead) -** The 2006 field study observed an average of 2.51 people per household. This analysis assumes that this density has not changed significantly in the past four years.

- **Shower Flow Rate (gpm) -** The baseline flow rate assumed for the 2007 analysis, 2.2. gpm, was the *median* flow rate observed during the 2006 field study. 2.2 gpm[3] (Schuldt & Tachibana, 2008). However, the *mean* flow rate observed at that time was 2.5 gpm. Since the 2006 field study, more low-flow showerheads have been distributed through programs, and, presumably, some >2.5 gpm showerheads have been replaced by ≤2.5 gpm showerheads outside of conservation programs.

  Using the median, rather than mean flow rate in the 2007 analysis was probably a conservative approach, given that customers with higher flow rates would be more likely to install a low-flow

[3] This is the measured maximum flow rate in the field, not the rated flow rate (at 80 psi). On average, homes in Seattle have a water pressure of 65 psi, implying lower than rated flow rates in actual operations. Most studies show average flow rates in the field of approximately 10% less than the rated flow rate.

showerhead; this suggests that even the *mean* observed flow rate might be a conservative estimate. Considering that mean flow rate has probably decreased since 2006 due to the program activity and retirement of >2.5 gpm showerheads mentioned above, an assumption of 2.2 gpm for the present time is reasonable. This is corroborated by other field studies described in *Appendix D: Data Sources*. The baseline flow rate for the current population of residential showerheads is assumed to be 2.2 gpm[4].

- **Average Shower Length (min per shower) –** The 2007 analysis assumes an average shower duration of 7.84 minutes, the observed average in the 2000 Seattle End-use Study. This value does not significantly conflict with any of the other studies reviewed, and is retained for this updated analysis.

- **Shower Water from Hot Tap (%)** – The 2007 analysis assumes a value of 68%, which was calculated from observed shower temperatures in a 1994 study. This study included many more >2.5 gpm showerheads than are currently in the population. As flow rates decrease, shower temperatures tend to increase to compensate for the increased heat loss incurred by the now smaller water droplets. A more recent Seattle study (US EPA, 2005) measured this to be 73.1% for the 2.24 gpm baseline showerheads in the study. An increased value of 73.1% is used for this analysis.

- **Water heater outlet temperature minus inlet temperature (°F) –** The 2007 analysis used a value of 75°F, based on a field study in the 1990s. This value is reasonable and is retained for this updated analysis.

- ***Water Heater Heating Energy (kWh per °F per gallon) –** The 2007 analysis assumes a 98% burn efficiency for electric water heating (while standby losses reduce the actual efficiency of the water heater, they are incurred regardless of the showerhead type and are therefore not considered in this analysis[5]). Using this burn efficiency, the specific heat of water, and conversion factors results in a water heater heating energy of 0.0025 kWh per °F per gallon. This value is reasonable and is retained for this updated analysis.

- ***Water Heater Heating Energy (therms per °F per gallon) –** The 2007 analysis assumes a 75% burn efficiency for electric water heating. Using this burn efficiency, the specific heat of water, and conversion factors results in a water heater heating energy of 0.00011 therms per °F per gallon. This value is reasonable and is retained for this updated analysis.

In summary, the baseline assumptions from the 2007 analysis are all used for this analysis, with the exception of the Shower Water from Hot Tap percentage, which is increased from 68% to 73%.

Table 1 summarizes the total consumption of water (gallons), hot water (gallons), kWh, and therms for the residential baseline. Note that the same baseline is used for each of the three measure flow-rates. A more detailed table of parameter assumptions, consumption, and cost are provided in Section 3.3.

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[4] Note that this is the *in situ* flow rate, not the *rated* flow rate. In situ flow rates are typically, on average, 10% less than rated flow rates because flow rate is rated at 80psi, and most plumbing systems have less pressure than this.

[5] Note that tankless, or "on demand", water heaters, which are gaining in popularity, would have the same burn efficiencies: their improved efficiency comes from the elimination of standby losses.

Table 3. Baseline Residential Water and Energy Consumption

Application	Primary Shower			Secondary Shower			Any Shower		
Showerhead rated flow rate at 80 psi	2.0 gpm	1.75 gpm	1.5 gpm	2.0 gpm	1.75 gpm	1.5 gpm	2.0 gpm	1.75 gpm	1.5 gpm
Water (gallons/year)	8,334	8,334	8,334	4,243	4,243	4,243	6,970	6,970	6,970
Water ($/year)	$ 83.60	$ 83.60	$ 83.60	$ 42.56	$ 42.56	$ 42.56	$ 69.92	$ 69.92	$ 69.92
Water (kWh/year)	44	44	44	22	22	22	37	37	37
Hot Water (gallons/year)	6,092	6,092	6,092	3,101	3,101	3,101	5,095	5,095	5,095
Hot Water (gallons degF / year)	456,901	456,901	456,901	232,604	232,604	232,604	382,135	382,135	382,135
Energy - Electric Water Heater (kwh/year)	1,139	1,139	1,139	580	580	580	953	953	953
Energy - Gas Water Heater (therms/year)	51	51	51	26	26	26	42	42	42
Energy - Any Water Heater (kwh/year)	729	729	729	371	371	371	610	610	610
Energy - Any Water Heater (therms/year)	18	18	18	9	9	9	15	15	15

3.1.2 Commercial Baselines

The following commercial applications are considered:

- **Hospitality** – hotels and motels.

- **In-patient health care and assisted living** – commercial settings where clients stay overnight, including hospitals, rehabilitation centers, assisted living residences, and nursing homes. Showers in these facilities are intended for regular use by clients.

  Particular attention to the potential for thermal-shock and scalding (see Appendix C: Scalding and Thermal Shock Risk) should be paid to this application - precautions include regular inspection of water heater temperature, testing of new showerheads under pressure fluctuations, and matching of new shower valves to showerheads to ensure adequate temperature and/or pressure compensation at the flow rate of the shower.

- **Small commercial, employee showers –** for example offices, fire and police stations, and other commercial locations where showers are available for employees to use.

More institutional style showerheads - such as those found at gyms, schools/dormitories, and prisons - are not considered in this analysis, due to a lack of available information on technology types and usage patterns of these showerheads.

For the commercial applications considered, assumptions about flow-rate, water temperature, and energy intensity used for the residential measures are also used here. It is assumed that the predominant showerhead found in the specified commercial types is the 2.5 gpm showerhead, with an actual flow-rate averaging 2.2 gpm.

The parameters that retain the same value as in the residential analysis (see Section 3.1.1) are:

- **Shower Flow Rate (gpm) –** 2.2 gpm
- **Shower Water from Hot Tap (%)** – 73%
- **Water heater outlet temperature minus inlet temperature (°F) –** 75°F
- **Water Heater Heating Energy (kWh per °F per gallon) –**0.0025 kWh per °F per gallon
- **Water Heater Heating Energy (therms per °F per gallon) –**0.00011 therms per °F per gallon

Parameters that have different values for commercial applications are:

- **Daily showers per Person (showers per person per day)**
- **Annualized Occupancy (days per year)**
- **Persons per Showerhead (people per showerhead)**
- **Average Shower Length (min per shower)**

The product of these four parameters results in the minute**s** per year that the showerhead is in use, herein referred to as *showerhead annual utilization*. For reference, primary residential showerheads, under the baseline residential assumptions (Section 3.1.1) have an annual utilization of 3,788 minutes per year, and secondary showers have an annual utilization of 1,928 minutes per year.

3.1.2.1 Hospitality

The following parameter estimates are used for hospitality applications to determine the annual utilization:

- **Minutes per Day:** 16.20[6]
- **Occupancy Rate**: 61%[7]

This results in 3,596 minutes per year per shower.

3.1.2.2 In-patient health care and assisted living

The following parameter estimates are used for health care applications to determine the annual utilization:

- **Minutes per Patient per Day:** 5.00[8]
- **Patients per shower at full capacity:** 2
- **Occupancy rate:** 78%[9]

This results in 2,849 minutes per year per shower.

3.1.2.3 Small commercial, employee showers

[6] Estimate developed as part of California savings potential study (Gleick, et al., 2003)

[7] This is the U.S. national average from 2000 to 2009 (PricewaterhouseCoopers, 2009)

[8] Estimate developed as part of California savings potential study (Gleick, et al., 2003)

[9] This is the national average occupancy rate for hospitals, nursing homes, and mental health/residential facilities, weighted by the total number of beds of each type, as determined from U.S. Department of Health and Human Services data (U.S. Department of Health and Human Services, 2008).

A range of small commercial site types may have showers for employee use. We were unable to locate data on usage patterns of these types of showers. As a conservative estimate of usage, it is assumed that these showers are used one half as much as the average primary residential showerhead, under the baseline residential assumptions (Section 3.1.1). This amounts to an annual utilization of 1,895 minutes per year per shower.

3.1.2.4 Summary of Baseline Commercial Water and Energy Consumption

Table 4 summarizes the total consumption of water (gallons), hot water (gallons), kWh, and therms for the residential baseline. Note that the same baseline is used for each of the three measure flow-rates. A more detailed table of parameter assumptions, consumption, and cost are provided in Section 3.3.

Table 4. Baseline Commercial Water and Energy Consumption

Savings	Hospitality			Health Care			Small Commercial - Employee		
Showerhead rated flow rate at 80 psi	2.0 gpm	1.75 gpm	1.5 gpm	2.0 gpm	1.75 gpm	1.5 gpm	2.0 gpm	1.75 gpm	1.5 gpm
Water (gallons/year)	7,911	7,911	7,911	6,268	6,268	6,268	4,169	4,169	4,169
Water ($/year)	$79.36	$79.36	$79.36	$62.88	$62.88	$62.88	$41.82	$41.82	$41.82
Water (kWh/year)	42	42	42	33	33	33	22	22	22
Hot Water (gallons/year)	5,783	5,783	5,783	4,582	4,582	4,582	3,048	3,048	3,048
Hot Water (gallons degF / year)	433,732	433,732	433,732	343,632	343,632	343,632	228,565	228,565	228,565
Energy - Electric Water Heater (kwh/year)	1,082	1,082	1,082	857	857	857	570	570	570
Energy - Gas Water Heater (therms/year)	48	48	48	38	38	38	25	25	25
Energy - Any Water Heater (kwh/year)	281	281	281	337	337	337	279	279	279
Energy - Any Water Heater (therms/year)	36	36	36	23	23	23	13	13	13

3.2 Post-retrofit Usage and Consumption

This analysis includes adjustments to the standard engineering approach to savings. Namely, in situ flow rate, shower duration, and hot water percentage are adjusted to address impacts of lower-flow showerheads. These adjustments are in agreement with the scant published data and the data from the interviews that there were conducted for this analysis; however, empirical research of lower-flow (<2.0 gpm) showerhead retrofits is necessary.

3.2.1 Residential post-retrofit usage and consumption

The following parameter estimates are used to determine post-retrofit energy and water consumption:

- **Daily showers per Person (showers per person per day)** – This value does not change from the baseline: 0.55 for primary showerheads in households, 0.28 for secondary showerheads (and assuming 33% of households have a second showerhead) and a total of 0.64 showers per person.

One of the few pre/post showerhead retrofit studies (Mayer, DeOreo, & Lewis, 2000) observed an increase in daily shower per person from 0.51 to 0.58 from pre- to post-retrofit and concluded that this increase in shower frequency negated any savings from lower flow rates.

The pre-retrofit study was conducted in November 1999 and the post-retrofit study was conducted in April and August 2000, suggesting that this change in shower frequency may be because of the season change, not the showerhead change. To further support this, the frequency of *baths* per person *decreased* from 0.14 to 0.10 from pre- to post-retrofit. Therefore, the more accurate estimate of savings would either be to 1) assume that the shower frequency varies by time of year and use the average frequency (0.55 showers per person per day) for both the pre- and post-retrofit case or 2) include energy savings from the decrease in baths in the energy analysis. The discussion of this study and the savings estimates from these suggested approaches are presented in *Appendix D: Data Sources*.

- **Annualized Occupancy (days per year) –** This value does not change from the baseline: 350 days per year.

- **Persons per Showerhead (people per showerhead) -** This value does not change from the baseline: 2.51 people per household.

- **Shower Flow Rate (gpm) –** Measured flow rates for residential showerhead applications is typically, on average, 10% less than the rated flow rate of the showerhead[10]. This discrepancy is primarily because showerheads are rated at a water pressure of 80 psi, where as the average residential water pressure is approximately 65 psi, and can be as low as 20 psi.

  However, the showerheads observed in the studies described in *Appendix D: Data Sources* were primarily rated at 2.0 gpm and above. While this same phenomenon does occur with lower flow showerheads (i.e., less than 2.0 gpm), some of the experts that we spoke with noted that homes with low pressure are typically not satisfied with the performance of lower-flow showerheads. With this in mind, manufacturers have designed pressure-compensating showerheads that are designed to provide a consistent flow rate across a wide range of pressures. The U.S. EPA's WaterSense specifications (see *Appendix B: User Satisfaction*) will require this consistency. Presumably, conservation programs will select showerheads that will be widely accepted by customers; at lower flow rates, pressure-compensating showerheads should be selected.

  Given the above discussion, the following post-retrofit flow rates are assumed:
  - **2.0 gpm rated showerhead:** An actual flow rate of 1.8 gpm (90% of the rated flow rate) is assumed, based on observed data
  - **1.75 gpm rated showerhead:** An actual flow rate of 1.66 gpm is assumed (95% of rated flow rate), based on the reasoning that these showerheads would need some flow rate consistency across home water pressures to be widely accepted in conservation programs.
  - **1.5 gpm rated showerhead:** An actual flow rate of 1.5 gpm is assumed (100% of the rated flow rate), based on the reasoning that widely-accepted showerheads at this low flow rate would need to provide 1.5 gpm, regardless of a home's water pressure.

[10] Observed in the majority of data from the data sources described in *Appendix D: Data Sources*.

- **Average Shower Length (min per shower) –** A discussion of the effect of flow rate on shower duration is provided in *Appendix A: Shower Duration***.** While it is suspected that duration increases as flow rate decreases, this duration increase was not observed in the studies reviewed for this analysis (see *Appendix D: Data Sources*). However, these studies did not examine showerheads with rated gpm below 2.0, where this effect is expected to be most significant.

  The scant data on this topic identified for this report suggests that shower duration may increase by as much as 20% for ultra low-flow (i.e., ≤1.5 gpm) showerheads. However, innovative ultra-low-flow showerhead designs have demonstrated reasonable spray force and minimize this effect.

  Low-flow showerheads could potentially *decrease* shower duration when replacing higher flow showerheads if the low-flow showerhead overall performance surpasses that of the showerhead being replaced. Arguably, users with poorly performing showerheads would be more inclined to try a new, lower-flow showerhead than users with satisfactory showerhead performance.

  Given the above discussion, the following post-retrofit shower durations are assumed:
  - **2.0 gpm rated showerhead:** No change in shower duration is assumed: the 7.84 minute duration assumed in the baseline is assumed for the post-retrofit case.
  - **1.75 gpm rated showerhead:** An estimated 5% increase in shower duration over the baseline is assumed, resulting in an 8.23 minute duration.
  - **1.5 gpm rated showerhead:** An estimated 10% increase in shower duration over the baseline is assumed, resulting in an 8.6 minute duration.

- **Shower Water from Hot Tap (%)** – The recent Seattle study (US EPA, 2005) used for the residential baseline estimate of this value observed a 75.5% value for the post-retrofit case. Pre-retrofit showerheads in this study had an observed flow rate of 2.2 gpm and post-retrofit showerheads had an observed flow rate of 1.8 gpm. For flow rates lower than 1.8 gpm, we assumed a linear relationship between flow rate and percentage of hot water. This results in the following percentages:

  - **2.0 gpm rated showerhead:** 75.5%, as observed in the study.
  - **1.75 gpm rated showerhead:** 76.3%
  - **1.5 gpm rated showerhead:** 77.3%

- **Water heater outlet temperature minus inlet temperature (°F) –** This value does not change from the baseline: 75°F.

- ***Water Heater Heating Energy (kWh per °F per gallon) –** This value does not change from the baseline: 0.0025 kWh per °F per gallon.

- **Water Heater Heating Energy (therms per °F per gallon) –**This value does not change from the baseline: 0.00011 therms per °F per gallon.

Table 5 summarizes the total consumption of water (gallons), hot water (gallons), kWh, and therms for the residential post-retrofit assumptions. Note that the same baseline is used for each of the three measure flow-rates. A more detailed table of parameter assumptions, consumption, and cost are provided in Section 3.3.

Table 5. Residential Post-Retrofit Water and Energy Consumption

Application	Primary Shower			Secondary Shower			Any Shower		
Showerhead rated flow rate at 80 psi	2.0 gpm	1.75 gpm	1.5 gpm	2.0 gpm	1.75 gpm	1.5 gpm	2.0 gpm	1.75 gpm	1.5 gpm
Water (gallons/year)	6,819	6,613	6,250	3,471	3,366	3,182	5,703	5,531	5,228
Water ($/year)	$68.40	$66.34	$62.70	$34.82	$33.77	$31.92	$57.21	$55.48	$52.44
Water (kWh/year)	36	35	33	18	18	17	30	29	28
Hot Water (gallons/year)	5,148	5,041	4,819	2,621	2,566	2,453	4,306	4,216	4,030
Hot Water (gallons degF / year)	386,101	378,075	361,427	196,561	192,474	183,999	322,921	316,208	302,284
Energy - Electric Water Heater (kwh/year)	963	943	901	490	480	459	805	788	754
Energy - Gas Water Heater (therms/year)	43	42	40	22	21	20	36	35	34
Energy - Any Water Heater (kwh/year)	616	603	577	314	307	294	515	505	482
Energy - Any Water Heater (therms/year)	15	15	14	8	8	7	13	13	12

3.2.2 Commercial post-retrofit usage and consumption

The parameters that retain the same value as in the residential analysis (see Section 3.2.1) are:

- **Shower Flow Rate (gpm) –** 1.8 gpm, 1.66 gpm, and 1.5 gpm (for the 2.0 gpm, 1.75 gpm, and 1.5 gpm ratings respectively)
- **Shower Water from Hot Tap (%)** – 75.5%, 76.3%, and 77.3%
- **Water heater outlet temperature minus inlet temperature (°F) –** 75°F
- **Water Heater Heating Energy (kWh per °F per gallon)** –0.0025 kWh per °F per gallon
- **Water Heater Heating Energy (therms per °F per gallon)** –0.00011 therms per °F per gallon

As discussed in the previous section, shower duration may increase as flow-rate decreases. For the minutes of shower usage per year stated in the discussion of the commercial baselines (Section 3.1.2), the same percentage increases in shower duration that are assumed for the residential measure are assumed for the commercial measure: no increase in duration for the 2.0 gpm rated showerhead, a 5% increase for the 1.75 gpm rated showerhead, and a 10% increase for the 1.5 gpm rated showerhead. Table 6 summarizes the resulting annual utilization for each of the commercial applications.

Table 6. Commercial post-retrofit annual utilization (minutes/year)

	Baseline	Post-retrofit		
		2.0 gpm rated	1.75 gpm rated	1.5 gpm rated
Hospitality	3,596	3,596	3,776	3,956
In-patient health care and assisted living	2,849	2,849	2,991	3,134
Small commercial, employee showers	1,895	1,895	1,990	2,085

Table 7 summarizes the total consumption of water (gallons), hot water (gallons), kWh, and therms for the residential post-retrofit assumptions. Note that the same baseline is used for each of the three measure flow-rates. A more detailed table of parameter assumptions, consumption, and cost are provided in Section 3.3.

Table 7. Commercial Post-Retrofit Water and Energy Consumption

Baseline	Hospitality			Health Care			Small Commercial - Employee		
Showerhead rated flow rate at 80 psi	2.0 gpm	1.75 gpm	1.5 gpm	2.0 gpm	1.75 gpm	1.5 gpm	2.0 gpm	1.75 gpm	1.5 gpm
Water (gallons/year)	6,473	6,277	5,933	5,128	4,973	4,701	3,411	3,308	3,127
Water ($/year)	$64.93	$62.97	$59.52	$51.44	$49.89	$47.16	$34.22	$33.18	$31.37
Water (kWh/year)	34	33	31	27	26	25	18	18	17
Hot Water (gallons/year)	4,887	4,785	4,575	3,872	3,791	3,624	2,575	2,522	2,411
Hot Water (gallons degF / year)	366,522	358,903	343,099	290,384	284,348	271,827	193,148	189,133	180,804
Energy - Electric Water Heater (kwh/year)	914	895	856	724	709	678	482	472	451
Energy - Gas Water Heater (therms/year)	41	40	38	32	32	30	21	21	20
Energy - Any Water Heater (kwh/year)	238	233	222	285	279	267	236	231	221
Energy - Any Water Heater (therms/year)	30	30	28	20	19	18	11	11	10

3.3 Summary of Parameter and Savings Estimates

The following tables summarize the baseline and post-retrofit assumptions and resulting gross energy and water savings for the residential and commercial measures.

Table 8. Residential Baseline Analysis

Application	Primary Shower			Secondary Shower			Any Shower		
Showerhead rated flow rate at 80 psi	**2.0 gpm**	**1.75 gpm**	**1.5 gpm**	**2.0 gpm**	**1.75 gpm**	**1.5 gpm**	**2.0 gpm**	**1.75 gpm**	**1.5 gpm**
Daily showers per Person (showers per person per day)	0.55	0.55	0.55	0.28	0.28	0.28	0.46	0.46	0.46
*Annualized Occupancy (days per year)	350	350	350	350	350	350	350	350	350
*Persons per Showerhead (people per showerhead)	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51
Average Shower Length (min per shower)	7.84	7.84	7.84	7.84	7.84	7.84	7.84	7.84	7.84
Showerhead Utilization (min per year)	3,788	3,788	3,788	1,928	1,928	1,928	3,168	3,168	3,168
Shower Flow Rate (gpm)	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Shower Water from Hot Tap (%)	73.1%	73.1%	73.1%	73.1%	73.1%	73.1%	73.1%	73.1%	73.1%
*Water heater outlet temperature minus inlet temperature (°F)	75	75	75	75	75	75	75	75	75
*Water Heater Heating Energy (kWh per °F per gallon)	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249
*Water Heater Heating Energy (therms per °F per gallon)	0.000111	0.000111	0.000111	0.000111	0.000111	0.000111	0.000111	0.000111	0.000111
Total Gallons per Year	8,334	8,334	8,334	4,243	4,243	4,243	6,970	6,970	6,970
Water Cost ($/year)	$83.60	$83.60	$83.60	$42.56	$42.56	$42.56	$69.92	$69.92	$69.92
Water and Sewer Energy (kWh/year)	44	44	44	22	22	22	37	37	37
Hot Water Gallons per Year	6,092	6,092	6,092	3,101	3,101	3,101	5,095	5,095	5,095
Hot Water Gallons degF per year	456,901	456,901	456,901	232,604	232,604	232,604	382,135	382,135	382,135
Electric Water Heating									
Annual kWh	1,139	1,139	1,139	580	580	580	953	953	953
Gas Water Heating									
Annual therms	50.8	50.8	50.8	25.9	25.9	25.9	42.5	42.5	42.5
All Water Heating									
Annual kWh	729	729	729	371	371	371	610	610	610
Annual therms	18.3	18.3	18.3	9.3	9.3	9.3	15.3	15.3	15.3

Table 9. Residential Post-Retrofit Analysis

Application	Primary Shower			Secondary Shower			Any Shower		
Showerhead rated flow rate at 80 psi	**2.0 gpm**	**1.75 gpm**	**1.5 gpm**	**2.0 gpm**	**1.75 gpm**	**1.5 gpm**	**2.0 gpm**	**1.75 gpm**	**1.5 gpm**
Daily showers per Person (showers per person per day)	0.55	0.55	0.55	0.28	0.28	0.28	0.46	0.46	0.46
*Annualized Occupancy (days per year)	350	350	350	350	350	350	350	350	350
*Persons per Showerhead (people per showerhead)	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51	2.51
Average Shower Length (min per shower)	7.84	8.23	8.62	7.84	8.23	8.62	7.84	8.23	8.62
Showerhead Utilization (min per year)	3,788	3,977	4,167	1,928	2,025	2,121	3,168	3,327	3,485
Shower Flow Rate (gpm)	1.80	1.66	1.50	1.80	1.66	1.50	1.80	1.66	1.50
Shower Water from Hot Tap (%)	75.5%	76.2%	77.1%	75.5%	76.2%	77.1%	75.5%	76.2%	77.1%
*Water heater outlet temperature minus inlet temperature (°F)	75	75	75	75	75	75	75	75	75
*Water Heater Heating Energy (kWh per °F per gallon)	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249
*Water Heater Heating Energy (therms per °F per gallon)	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011
Total Gallons per Year	6,819	6,613	6,250	3,471	3,366	3,182	5,703	5,531	5,228
Water Cost ($/year)	$68.40	$66.34	$62.70	$34.82	$33.77	$31.92	$57.21	$55.48	$52.44
Water and Sewer Energy (kWh/year)	36	35	33	18	18	17	30	29	28
Hot Water Gallons per Year	5,148	5,041	4,819	2,621	2,566	2,453	4,306	4,216	4,030
Hot Water Gallons degF per year	386,101	378,075	361,427	196,561	192,474	183,999	322,921	316,208	302,284
Electric Water Heating									
Annual kWh	963	943	901	490	480	459	805	788	754
Gas Water Heating									
Annual therms	42.9	42.0	40.2	21.9	21.4	20.5	35.9	35.2	33.6
All Water Heating									
Annual kWh	616	603	577	314	307	294	515	505	482
Annual therms	15.5	15.1	14.5	7.9	7.7	7.4	12.9	12.7	12.1

Table 10. Commercial Baseline Analysis

Application	Hospitality			Health Care			Small Commercial - Employee		
Showerhead rated flow rate at 80 psi	**2.0 gpm**	**1.75 gpm**	**1.5 gpm**	**2.0 gpm**	**1.75 gpm**	**1.5 gpm**	**2.0 gpm**	**1.75 gpm**	**1.5 gpm**
Showerhead Utilization (min per year)	3,596	3,596	3,596	2,849	2,849	2,849	1,895	1,895	1,895
Shower Flow Rate (gpm)	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Shower Water from Hot Tap (%)	73.1%	73.1%	73.1%	73.1%	73.1%	73.1%	73.1%	73.1%	73.1%
*Water heater outlet temperature minus inlet temperature (°F)	75	75	75	75	75	75	75	75	75
*Water Heater Heating Energy (kWh per °F per gallon)	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249
*Water Heater Heating Energy (therms per °F per gallon)	0.000111	0.000111	0.000111	0.000111	0.000111	0.000111	0.000111	0.000111	0.000111
Total Gallons per Year	7,911	7,911	7,911	6,268	6,268	6,268	4,169	4,169	4,169
Water Cost ($/year)	$79.36	$79.36	$79.36	$62.88	$62.88	$62.88	$41.82	$41.82	$41.82
Water and Sewer Energy (kWh/year)	42	42	42	33	33	33	22	22	22
Hot Water Gallons per Year	5,783	5,783	5,783	4,582	4,582	4,582	3,048	3,048	3,048
Hot Water Gallons degF per year	433,732	433,732	433,732	343,632	343,632	343,632	228,565	228,565	228,565
Electric Water Heating									
Annual kWh	1,082	1,082	1,082	857	857	857	570	570	570
Gas Water Heating									
Annual therms	48.2	48.2	48.2	38.2	38.2	38.2	25.4	25.4	25.4
All Water Heating									
Annual kWh	281	281	281	337	337	337	279	279	279
Annual therms	35.7	35.7	35.7	23.2	23.2	23.2	13.0	13.0	13.0

Table 11. Commercial Post-Retrofit Analysis

Application	Hospitality			Health Care			Small Commercial - Employee		
Showerhead rated flow rate at 80 psi	**2.0 gpm**	**1.75 gpm**	**1.5 gpm**	**2.0 gpm**	**1.75 gpm**	**1.5 gpm**	**2.0 gpm**	**1.75 gpm**	**1.5 gpm**
Showerhead Utilization (min per year)	3,596	3,776	3,956	2,849	2,991	3,134	1,895	1,990	2,085
Shower Flow Rate (gpm)	1.80	1.66	1.50	1.80	1.66	1.50	1.80	1.66	1.50
Shower Water from Hot Tap (%)	75.5%	76.2%	77.1%	75.5%	76.2%	77.1%	75.5%	76.2%	77.1%
*Water heater outlet temperature minus inlet temperature (°F)	75	75	75	75	75	75	75	75	75
*Water Heater Heating Energy (kWh per °F per gallon)	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249	0.00249
*Water Heater Heating Energy (therms per °F per gallon)	0.000111	0.000111	0.000111	0.000111	0.000111	0.000111	0.000111	0.000111	0.000111
Total Gallons per Year	6,473	6,277	5,933	5,128	4,973	4,701	3,411	3,308	3,127
Water Cost ($/year)	$64.93	$62.97	$59.52	$51.44	$49.89	$47.16	$34.22	$33.18	$31.37
Water and Sewer Energy (kWh/year)	34	33	31	27	26	25	18	18	17
Hot Water Gallons per Year	4,887	4,785	4,575	3,872	3,791	3,624	2,575	2,522	2,411
Hot Water Gallons degF per year	366,522	358,903	343,099	290,384	284,348	271,827	193,148	189,133	180,804
Electric Water Heating									
Annual kWh	914	895	856	724	709	678	482	472	451
Gas Water Heating									
Annual therms	40.8	39.9	38.2	32.3	31.6	30.2	21.5	21.0	20.1
All Water Heating									
Annual kWh	238	233	222	285	279	267	236	231	221
Annual therms	30.2	29.5	28.2	19.6	19.2	18.3	11.0	10.7	10.3

Table 12. Summary of Residential Gross Savings

Application	Primary Shower			Secondary Shower			Any Shower		
Showerhead rated flow rate at 80 psi	**2.0 gpm**	**1.75 gpm**	**1.5 gpm**	**2.0 gpm**	**1.75 gpm**	**1.5 gpm**	**2.0 gpm**	**1.75 gpm**	**1.5 gpm**
Water (gallons/year)	1,515	1,721	2,083	771	876	1,061	1,267	1,440	1,743
Water ($/year)	$15.20	$17.27	$20.90	$7.74	$8.79	$10.64	$12.71	$14.44	$17.48
Water (kWh/year)	8	9	11	4	5	6	7	8	9
Hot Water (gallons/year)	944	1,051	1,273	481	535	648	790	879	1,065
Hot Water (gallons degF / year)	70,799	78,826	95,474	36,043	40,130	48,605	59,214	65,927	79,851
Energy - Electric Water Heater (kwh/year)	177	197	238	90	100	121	148	164	199
Energy - Gas Water Heater (therms/year)	8	9	11	4	4	5	7	7	9
Energy - Any Water Heater (kwh/year)	113	126	152	58	64	78	94	105	127
Energy - Any Water Heater (therms/year)	3	3	4	1	2	2	2	3	3

Table 13. Summary of Commercial Gross Savings

Application	Hospitality			Health Care			Small Commercial - Employee Shower		
Showerhead rated flow rate at 80 psi	2.0 gpm	1.75 gpm	1.5 gpm	2.0 gpm	1.75 gpm	1.5 gpm	2.0 gpm	1.75 gpm	1.5 gpm
Water (gallons/year)	1,438	1,634	1,978	1,140	1,295	1,567	758	861	1,042
Water ($/year)	$14.43	$16.39	$19.84	$11.43	$12.99	$15.72	$7.60	$8.64	$10.46
Water (kWh/year)	8	9	10	6	7	8	4	5	6
Hot Water (gallons/year)	896	998	1,208	710	790	957	472	526	637
Hot Water (gallons degF / year)	67,209	74,829	90,633	53,248	59,285	71,805	35,418	39,433	47,761
Energy - Electric Water Heater (kwh/year)	168	187	226	133	148	179	88	98	119
Energy - Gas Water Heater (therms/year)	7	8	10	6	7	8	4	4	5
Energy - Any Water Heater (kwh/year)	44	49	59	52	58	70	43	48	58
Energy - Any Water Heater (therms/year)	6	6	7	4	4	5	2	2	3

4 MEASURE INPUTS FOR COST, NON-ENERGY BENEFITS, AND LIFETIME

The section discusses the material and installation costs, equipment lifetime, water and sewer costs, embodied energy of water.

4.1 Incremental Cost

The previous (2007) showerhead deemed measure assumed a cost of $24. Present single-function low-flow, pressure compensating showerheads cost as little as $15. Sources interviewed for this analysis suggested that showerheads with good customer satisfaction could be purchased in bulk for $15 to $20. Including distribution costs, the previously assumed cost of $24 is considered reasonable and is retained for this analysis.

Previous cost-research in the Northwest by Summit Blue showed no statistically significant correlation between flow rate and showerhead cost. In this analysis, no variation in cost across flow-rates is assumed.

4.1.1 Installed Cost

For giveaway and rebate delivery mechanisms, no labor costs are included. For direct install delivery mechanism, a $10 labor cost is included. This assumes 20 minutes per showerhead installation at a labor rate of $30. The time required for replacement includes removing the existing showerhead, applying new Teflon tape to the shower arm, installing the new showerhead, and testing the shower for acceptable thermal fluctuation response to pressure change (for example, by flushing the toilet). 20 minutes would also allow for measurement of in situ baseline and retrofit flow rates, which could be used to refine future savings estimates.

4.1.2 O&M Costs

No incremental O&M costs are assumed in this analysis. Showerheads, including low-flow showerheads, are mostly maintenance.

4.2 Non-energy Benefits

Water and sewer savings from low-flow showerheads are a significant portion of total cost savings. Water and sewer costs were collected for the previous showerhead analysis (2007) and amounted to $10.03 per 1000 gallons, on a population-weighted basis. This estimate is retained for this current analysis.

Additionally, an energy intensity of 5.3 kWh per 1000 gallons was assumed for the previous analysis and is retained here. This included water treatment and distribution, as well as waste-water treatment.

4.3 Measure Life

During the 2006 Seattle study (Schuldt & Tachibana, 2008), 80% of the low-flow showerheads installed during the 1990s as part of SPU conservation programs were will in use[11]. The previous analysis assumed an effective useful life (EUL) of 10 years and this value is retained for this analysis.

[11] The program manager noted that high quality (~$15) showerheads were used for his program, whereas other programs across the country have used less expensive showerheads and had lower customer satisfaction.

5 MEASURE IMPACT AND COST-EFFECTIVENESS

XXX INSERT ProCost inputs and results

6 SUGGESTIONS FOR FURTHER RESEARCH

Since the passage of EPAct 1992, mandating a maximum rated flow rate of 2.5 gpm, surprisingly few empirical impact studies have been conducted on showerhead retrofits. This small body of research is becoming irrelevant as baseline characteristics change and as lower-flow rate showerheads[12] with good performance become available.

Additional research is necessary to validate assumptions made in this analysis, including:

- **Shower duration** - the effect of shower flow rate (and other performance factors) on shower duration. *Appendix A: Shower Duration* examines this issue.

- **Shower temperature** - the effect of shower flow rate (and other performance factors) on shower setpoint temperature.

- **Product satisfaction** – the effect of factors such as flow rate, other showerhead performance factors, plumbing system pressure, individual's hair length on product satisfaction.

  The release of the U.S. EPA's WaterSense showerhead specifications (see *Appendix B: User Satisfaction*) is imminent (as of January 2010). These specifications are intended to ensure satisfactory performance at low flow rates. Manufacturers will have concrete objectives to design towards and conservation programs may finally have some indication as to which low-flow showerheads might provide satisfactory performance for their customers.

- **Baseline commercial consumption** – public research has not been conducted on even the baseline commercial sector shower water and energy use.

  Puget Sound Energy recently released a request for proposals on exactly this topic; better data may be available in the coming year.

- **Measure persistence** – the effective useful life of low-flow showerheads, affected by prevalence of showerhead tampering, showerhead removal, showerhead failure.

Some of these topics could be examined through data collection incorporated in conservation program design. For example, commercial participants could be surveyed to estimate the usage patterns of their showers; direct install programs could collect baseline and post-retrofit data on flow rate, spray force, and spray distribution. Conservation programs could also be used to solicit participants for pre-/post- studies.

Furthermore, the topic of scalding and thermal shock should be monitored closely to ensure that consumer safety is not be compromised in the name of conservation. As mentioned in *Appendix C: Scalding and Thermal Shock Risk*, several conservation programs across the U.S. and Canada are currently distributing

[12] Most existing studies do not consider retrofits with rated flow rates less than 2.0 gpm.

1.5 gpm showerheads; the experiences of these programs may inform the path forward for Northwest conservation programs.

7 REFERENCES

AntiScald Inc. (n.d.). *AntiScald Inc.* Retrieved January 2010, from http://www.antiscald.com/

Ball, J. (2009, November 13). Under Pressure: Bathers Duck Weak Showerheads. *The Wall Street Journal* .

Baxter, M. (2007, December 6). Behind Duke's Showerhead Giveaway. *Duke Today* .

Biermayer, P. (2005). *Potential Water and Energy Savings from Showerheads.* Berkeley, CA: Lawrence Berkeley National Laboratory, LBNL-58601.

Consumer Reports. (August 2009). Showerheads. *Consumer Reports* .

Gauley, B. (2009). *Testing Efficient Showerheads.* Portland, OR: Veritec Consulting Inc., presented at the American Water Works Association's 2009 Water Conservation Workshop - http://www.veritec.ca/uploads/Showers%20wo%20pics.pdf.

Gleick, P., Haasz, D., Henges-Jeck, C., Srinivasan, V., Wolff, G., Cushing, K. K., et al. (2003). *Waste Not, Want Not: The Potential for Urban Water Conservation in California.* Pacific Institute.

HotStop. (n.d.). *HotStop Anti-Scald Products.* Retrieved January 2010, from http://www.h2otstop.com/

Koeller, J. (2009, January/February). Danger in the Shower: 2008 Forum Looks at Hot Water. *Home Energy* , p. 6.

Martin, S. (2009, August). What you need to know before going super-low-flow in the shower. *Professional Remodeler* , pp. 34-36.

Mayer, P. W., DeOreo, W. B., & Lewis, D. M. (2000). *Seattle Home Water Conservation Study.* Seattle Public Utilities and the U.S. EPA.

Mayer, P., & DeOreo, W. (1999). *Residential End Uses of Water.* Denver, CO: American Water Works Association.

Mayer, P., DeOreo, W., Opitz, E., Kiefer, J., Davis, W., Dziegielewski, B., et al. (2000). *Residential End Uses of Water.* Water Researc Foundation and the American Water Works Association.

Miami-Dade County. (2008, September 2). Ordinance relating to Water Efficiency Standards, effective January 1, 2009. FL: http://online.wsj.com/public/resources/documents/powershift111209.pdf.

PricewaterhouseCoopers. (2009). *PricewaterhouseCoopers U.S. lodging industry update forecasts beginning of lodging demand recovery in 2010.* New York: PricewaterhouseCoopers.

Schuldt, M., & Tachibana, D. (2008). Energy-Related Water Fixture Measurements: Securing the Baseline fo Northwest Single Family Homes. *Proceedings of th 2008 ACEEE Summer Study on Energy Efficiency in Buildings.* American Council for an Energy-Efficiency Economy.

U.S. Department of Health and Human Services. (2008). *Health, United States, 2008.* U.S. Department of Health and Human Services.

Union Gas. (n.d.). *FREE Showerheads and Aerators.* Retrieved January 2010, from uniongas: A Spectra Energy Company: http://www.uniongas.com/business/energyconservation/programs/freeShowerAeratorDetails.asp

US EPA. (2005). *Water and Energy Savings from High Efficiency Fixtures and Appliances in Single Family Homes.*

US EPA. (2009). *WaterSense Draft Specification for Showerheads*. Retrieved from WaterSense, A EPA Partnership Program: http://www.epa.gov/watersense/products/showerheads.html

Viola, D. W. (2002). *Water Temperature Control and Limitation.* Plumbing Manufacturers Institute.

APPENDIX A: SHOWER DURATION

The effect of showerhead performance on shower duration is a key area of uncertainty. Duration may be affected not only be flow rate, but also by spray force, which - for a given showerhead design - decreases with flow rate. The most common effect is that a reduction in flow and spray can lead to longer times required to rinse shampoo out of hair; this effect becomes more dramatic with hair length. However, the effect is for a given showerhead design: to the extent that low-flow showerheads have improved designs to compensate for reduced flows, this effect can be minimized.

As mentioned previously, the U.S. EPA's WaterSense specifications will address not only rated flow rate at 80 psi, but also flow rates across the spectrum of typically observer water pressures in the field (~30 to 80 psi), as well as spray force. With minimum performance criteria specified, retrofits that use qualified low-flow showerheads should have less shower duration impact due to rinsing.

There are other reasons for low-flow showerheads leading to increased shower duration. One is that some users with traditional tank hot water heaters will shower until they run out of hot water. Reducing the flow rate of their shower would only lead to a longer shower. Another reason is the psychological phenomenon in which the ecological and/or economic guilt associated with taking a long shower is reduced by the knowledge of using a more efficient showerhead; this reduction in guilt "allows" the user to take a longer shower.

As referenced in *Appendix D: Data Sources*, one of the few studies to examine pre- and post-retrofit duration (US EPA, 2005) found no statistically significant increase in shower duration with reduced rated or actual flow rate. Another study, the Residential End Uses of Water Study (REUWS) (Mayer P. , et al., 2000) found a significant correlation between flow rate and shower time, but this was only for existing showerheads and only for a comparison of showerheads above 2.5 gpm and below 2.5 gpm; retrofits were not examined, nor were lower-flow showerheads. The Seattle participants of the REUWS later took part in a retrofit study (Mayer, DeOreo, & Lewis, 2000) which found no increase in shower duration after the retrofit.

In this analysis, no increase in duration over baseline is assumed for 2.0 gpm rated showerheads, a 5% increase in duration is assumed for 1.75 gpm rated showerheads, and a 10% increase in duration for a 1.5 gpm rated showerhead is assumed.

APPENDIX B: USER SATISFACTION

As with any efficiency product, customer approval is key to program success and market transformation. Incentive providers should consider supplying showerheads that meet performance criteria and have demonstrated customer approval through trials.

We analyzed the results from a recent study by Consumer Reports (Consumer Reports, August 2009), which tested 17 showerheads and observed the following:

- Cost is not a good predictor of flow rate and/or performance.
- Flow rate did have a statistically significant correlation to performance (at 90% confidence level, not 95% level).
    - On average, a 0.1 gpm decrease in flow rate results in a 1.3 point (out of 100) decrease in overall rating. For example, the average decrease in rating from a 2.0 gpm to a 1.5 gpm showerhead would be 6.5 points (out of 100).
- Single setting models had overall ratings comparable to multi-setting models, with significantly lower costs.
    - The average cost of a single setting model was $38; the average cost of a multi-setting model was $65)[13].

Another study of user satisfaction of showerheads was conducted by Veritec Consulting (Gauley, 2009). In this study, 12 showerheads were each tested on 24 participants (13 female/10 male, mean age of 22 years old). The participants rated each showerhead on a variety of performance metrics. The two most significant metrics to overall satisfaction were strength of spray and hair rinsing ability. We analyzed these results and found that, on average, a 0.1 gpm decrease in flow rate results in a 3.4 point (out of 100)[14] decrease in overall rating (a decrease from 2.0 gpm to 1.5 gpm would reduce overall rating by 17 points (out of 100).

One observation from sources interviewed for this study was that low-flow showerheads typically get poor ratings in homes with low water pressure. Some models now have pressure-compensation features that maintain a flow-rate near the rated flow rate at across a wide range of pressures (~30 psi to 80 psi). Pressure compensating shower-heads may improve program uptake. Showerheads without pressure-compensation tend to have an average in-situ flow rate of approximately 10% less than the rated flow rate, primarily because showerheads are rated at 80 psi and the pressure in a typical plumbing system is lower than 80 psi; Because pressure-compensating showerheads are designed to provide the rated flow rate across the range typical water pressures, the flow rate of these models might not warrant a derating for savings analysis.

For this analysis, we have assumed that the in situ flow rate for 2.0 gpm rated showerheads is 10% less than rated, for 1.75 gpm rated showerheads it is 5% less, and for 1.5 gpm rated showerheads, the rated flow rate *is* the in situ flow rate. The rationale for these assumptions is that pressure compensation will be

[13] The article did not describe the sampling methodology, and these prices appear higher than typical retail showerhead prices, suggesting the more upscale models were tested.

[14] The overall rating from the Veritec study were on a 5.0 scale. This was multiplied by 20 to get a 100-point scale in order to provide a direct comparison between the Consumer Report and Veritec studies.

more prevalent as rated flow rates decrease, to ensure acceptable performance under low plumbing system pressure.

To date, shower-heads have eluded performance specification, leading to a wide range of customer satisfaction for different models. The U.S. EPA is currently developing a WaterSense showerhead specification, which is expected to be announced in early 2010 (US EPA, 2009). Specifications included acceptable performance on four metrics:

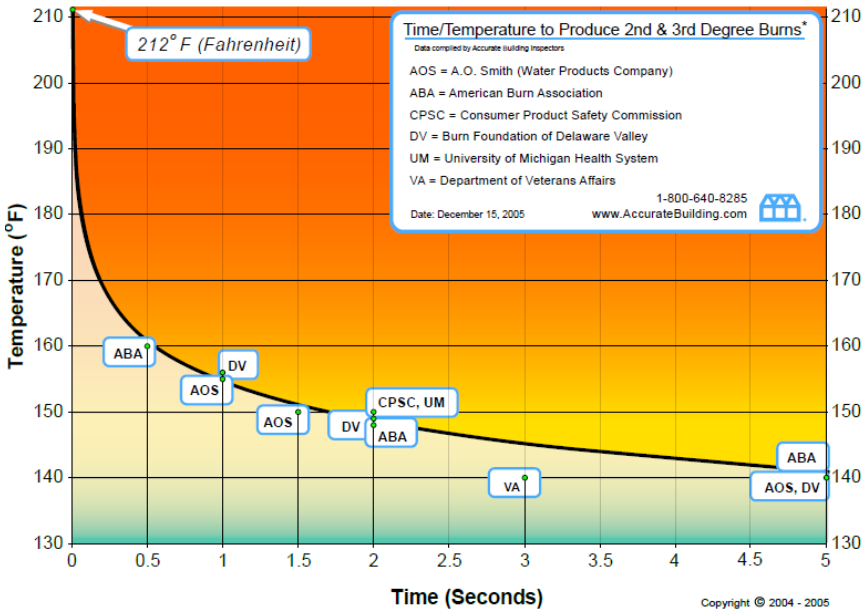
- Maximum flow rate (flow rate at 80 psi)
- Acceptable flow rate across a range of pressures
- Minimum spray force
- Spray coverage /distribution.

WaterSense has previously developed specifications for other water consuming devices and the WaterSense label has developed significant market presence: In 2008, WaterSense specifications for faucets and faucet accessories were introduced and WaterSense label immediately bore a significant market share:, 12% of faucets, and 25% of faucet accessories (including aerators) sold in the U.S. in 2008. WaterSense specifications for toilets were released in 2007, and by 2008, 9% toilets sold in the U.S. bore the WaterSense label. This suggests that the coming year may introduce many showerheads to the marketplace with reliable performance, allowing conservation programs more certainty in savings due to improved measure retention and minimized counteracting influences such as increased shower duration and temperature setpoint.

APPENDIX C: SCALDING AND THERMAL SHOCK RISK

Many showers are subject to sudden and unexpected deviations from the user-set shower temperature, and can pose a safety hazard. These changes in temperature can occur when another water consuming device is turned on while the user is showering; these devices draw hot or cold water, reducing the pressure of this water line to the shower and therefore changing the relative mix of hot and cold water. For example, a flushed toilet can suddenly draw cold water, reducing the pressure on the cold water line to the shower, and decreasing the amount of cold water mixed in with the hot water from the shower, thus increasing the temperature of the delivered shower water[15].

These temperature fluctuations pose two safety hazards: thermal-shock and scalding. Thermal-shock injury from shock occurs when users are startled and fall or sustain injuries from jerking reflexively and hitting a shower wall, fixture, or other object. Scalding is a burn injury incurred from prolonged exposure to hot water. As water temperature increases, the time required to develop second and third degree burns decreases dramatically: at 120°F, it would take 10 minutes of constant exposure to develop these burns. At 125°F this time is reduced to 2 minutes, and at 140°F, this time is reduced to six seconds. At 155°F, scalding burns can occur in as little as one second. Figure 1 graphs the time required to produce second and third degree burns at various water temperatures.



Source: Accurate Building Inspectors

Figure 1. Hot Water Burn and Scalding Graph

[15] This phenomenon is most apparent in plumbing systems with 1/2 " or 3/8" supply pipes, and is not as significant with wider pipes.

Automatic compensation shower valves reduce these risks by reducing the flow rate during pressure fluctuations. These devices have been required by codes since 1987, but are only required to be tested at a flow rate of 2.5 gpm; they are typically less effective at lower flow-rates.

Showerheads are available with build-in temperature regulation devices, which automatically reduce water to a trickle if the temperature exceeds 120°F[16]. Temperature regulation devices that install in-line with the showerhead are also available[17] (AntiScald Inc.). Neither of these devices appears to have significant market share, and the performance of these devices was not verified for this analysis.

For technical discussions of thermal considerations in plumbing, the reader is referred to an article by the technical director of the Plumbing Manufacturers Institute (Viola, 2002) and (Martin, 2009)

Empirical Evidence

We found no reported incidences of thermal-shock or scalding resulting from low-flow showerheads. Two of the showerhead experts that we interviewed for this analysis did mention concerns about thermal scalding[18]. One of the few published mentions of this issue was from one of these experts in an article written for Home Energy (Koeller, 2009). This article describes the potential for these hazards but does not indicate any occurrences.

Despite this possible hazard, several organizations are providing free sub-2.0 gpm showerheads to customers as a conservation measure, including:

- **Miami-Dade County (Florida) -** Miami-Dade passed regulation prohibiting the sale of showerheads with flow rates above 1.5 gpm, staring on January 1, 2009 (Miami-Dade County, 2008).
- **Duke University** – Duke has provided free 1.5 gpm showerheads to faculty, staff and off-campus students (Baxter, 2007)
- **Union Gas (Ontario, Canada)** – Union Gas provides free 1.25 gpm showerheads to customers[19] (Union Gas).

The sponsors of these and other incentive programs might be contacted to discuss any measures that they have taken to reduce risk and liability associated with scalding and thermal shock.

As further evidence of the lack of published accounts of injury from thermal-shock or scalding in the shower, the website for AntiScald Inc., vendors of an inline, shower scald protection device. (claims to reduces flow to a trickle if water temperature exceeds 120°F). On their webpage section "Scalding in the news" contains two new articles concerning scalding events that resulted in death. Neither of these incidences involved showers. One involved a sanitizer for laboratory equipment. The other involved scalding burns from an unspecified source to a child; the burns were not medically treated and the caretaker was convicted of reckless injury to a child; no other mention or documentation of any other

[16] See HotStop's showerhead products (HotStop)

[17] See AntiScald Inc.'s (AntiScald Inc.) ScaldShield product.

[18] Both suggested that 2.0 gpm showerheads did not compromise the performance of compensation valves considerably, but did not advise installing lower flow showerheads.

[19] Additionally, these showerheads specifically have a non-removable flow compensator.

litigation on this case was found. Intuitively, if articles were available that highlighted the dangers of shower-induced scalding that their product mitigates, it would be advantageous to them to post them.

Precautions

For showers with automatic compensation valves, users who install new, lower-flow showerheads can quickly test the performance of their shower configuration by turning their shower on to a normal setting, flushing the toilet or turning on another water consuming device, and monitoring the output of the shower. If temperature deviations are deemed higher than desirable by the user, than they should reinstall their original showerhead. The precaution can be provided as part of the showerhead delivery. Several experts that we spoke with felt that this testing was an adequate safety precaution.

Another precaution might be to only target select markets (especially for ultra low showerheads, i.e., less than 1.5 gpm) that have higher water pressure and/or can more readily test showerhead/compensation valve combinations. Low-flow showerheads may not be recommended in commercial health-care applications or for use by the elderly and disabled without this compatibility test.

For new construction projects, it is recommended to install compensation valves that the showerhead manufacturer identifies as being compliant with the showerhead model of interest.

APPENDIX D: DATA SOURCES

This analysis leveraged several available showerhead studies. We considered only studies conducted in the past 10 years: Studies prior to that (including those conducted for BPA) focused almost exclusively on replacing showerheads capable of 4 to 5gpm (but typically throttled by users to about 3.5 gpm) with 2.5 gpm showerheads. Since that time, showerhead technology and baseline showerhead characteristics have changed significantly. While these initial retrofits did not result in increased shower duration, there was – and still is – concern that lower flow (i.e. rated at less than 2.5 gpm) showerheads might result in longer showers. This appendix summarizes the data sources that were used for this analysis.

U.S. EPA 2005

The U.S. EPA measured water and energy savings from high efficiency water retrofits (US EPA, 2005). The study examined primarily older (average home age of 46 years), owner-occupied, single-family homes; 33 homes in the East Bay area of the San Francisco Bay area, CA, 37 homes in Seattle, WA, and 26 homes in Tampa, FL were studied. Pre and post retrofit measurements were taken. Homes in the East Bay and Seattle were retrofit with 2.5 gpm showerheads and homes in Tampa were retrofit with a mix of 1.75 gpm models and handheld 2.5 gpm showerheads with a shut-off feature. This study showed no significant water or energy savings for the East Bay and Seattle cases; this is not surprising given that the baseline flow rates observed at these homes were already less than 2.5 gpm[20]. The Tampa study resulted in statistically significant 28% reduction in total water use; hot water savings for Tampa sites were not reported.

Interestingly, the average shower duration for each of three cities *decreased* after the retrofit, even as flow rates decreased in each of the three cities. The absence of statistically significant savings in Oakland and Seattle suggests that these changes in duration may not be statistically significant. Regardless, they do not support the argument that lower flow showerheads lead to longer showers. Table 14 summarizes these results.

Table 14. Observed shower flow rates and durations in the U.S. EPA 2005 study

	pre-retrofit		post-retrofit	
	flow rate (gpm)	duration (min)	flow rate (gpm)	duration (min)
East Bay	2.0	8.9	1.8	8.2
Seattle	2.2	7.9	1.9	7.8
Tampa	2.1	8.0	1.7	7.8

[20] The study found that users typically throttled the water flow to showerheads with flow rates greater than 2.5 gpm: observed showerheads capable of 4 or 5 gpm were typically not be used at their full potential flow rate.

Seattle City Light and SBW Consulting, Inc., 2006

In 2006, Seattle City Light managed a study of residential water fixtures (Schuldt & Tachibana, 2008). This study examined 71 homes in the Seattle area. Full throttle flow rates for existing and proposed retrofit showerheads (installed during the site visit) were measured. The average home age was 70 years. The mean pre-retrofit shower flow rate was 2.5 gpm, the median was 2.2 gpm. The mean and median post-retrofit shower flow rate was 1.8 gpm. This 0.4 gpm difference between the pre- and post-retrofit median flow rate is the basis for the current RTF deemed showerhead savings.

Veritec Consulting, Inc., 2008

In 2008, Veritec Consulting, Inc. tested twelve showerhead models, with a variety of rated flow rates on 23 participants (13 female/10 male, mean age of 22 years old) in an experimental setup. Each showerhead was rated on several qualities by the participant, and flow rates were measured. The study did not find cost to be a factor in overall rating, and that several of the better rated showerheads were in the middle to low flow range (~1.7 gpm).

Aquacraft, Inc. Water Engineering and Management, for Seattle Public Utilities and the U.S. EPA, 1999-2000

SPU and the U.S. EPA managed a study of 37 single-family homes in Seattle that had previously participated in the Residential End Uses of Water Study (REUWS)[21] and then participated in a retrofit program (Mayer, DeOreo, & Lewis, 2000). Interestingly, this study found that although the retrofit, low flow showerheads reduced the user flow rate and did not significantly increase shower duration, there was no statistically significant water or energy savings because the frequency of showers increased.

However, this study also found that the frequency of baths decreased during this same time period (no modifications were made to bath faucets) and the change in both shower and bath frequency were statistically significant. Two conclusions are most likely:

1) People substitute baths for showers during colder months (the baseline study was done in November 1999, the post-retrofit study was done in April and August 2000). In this case, shower and bathing frequency should not be considered variable from pre- to post-retrofit; the average between the two cases would be a more appropriate estimate for both cases.

[2121] The Residential End-uses of Water Study (REUWS), conducted by Aquacraft for the American Water Works Association (Mayer & DeOreo, 1999) is the most comprehensive study of end-use water consumption. However, at that time, very few showerheads considered low flow be today's standards (i.e., lower than 2.5 or 2.0 gpm rating) were observed; this report was not used in this analysis. However, baseline results from (Mayer, DeOreo, & Lewis, 2000) were compared to the REUWS and found to be in close agreement.

2) People substitute showers for baths as a result of the retrofit. In this case, the aggregate savings between bath and shower should be considered as the impact of the showerheads.

Table 15 summarizes the findings of the study. Table 16 summarizes our analysis of these results, examining the two conclusions above and estimating hot water savings of 0.8 to 1.0 gallons of hot water per person per day.

Table 15. Results from SPU/U.S. EPA Seattle Study

	Pre-retrofit	Post-retrofit
Shower		
flow rate (gpm)	2.24	1.88
duration (minutes)	7.91	7.84
water volume per shower (gallons)	18.1	14.93
shower hot water percentage*	73.1%	75.5%
shower frequency (per capita per day)	0.51	0.59
Bath		
water volume per bath (gallons)	24	24.3
bath hot water percentage*	78.2%	78.3%
bath frequency (per capita per day)	0.14	0.10
Sample Design		
site n (number of sites in study)	37	35
duration and time of study	2 weeks, in November 1999	2 weeks, in April and August 2000

**only 10 sites were logged for separate hot and cold water metering*

Table 16. Further savings analysis of SPU/U.S. EPA Seattle Study

	Pre-retrofit	Post-retrofit	Savings
Water consumption, holding shower and bath frequency constant across pre- and post-retrofit (gallons per person per day)			
shower - hot water only	7.1	6.1	1.0
shower - all water	9.7	8.1	1.6
bath - hot water only	2.3	2.3	0.0
bath - all water only	2.9	2.9	0.0
all hot water	9.4	8.4	1.0
all water	12.6	11.0	1.6
Water consumption, as measured (gallons per person per day)			
shower - hot water only	6.6	6.6	0.0
shower - all water	9.0	8.7	0.3
bath - hot water only	2.6	1.9	0.7
bath - all water only	3.4	2.4	0.9
all hot water	9.2	8.5	0.8
all water	12.4	11.1	1.3

Pacific Institute, 2003

The Pacific Institute's report, Waste Not, Want Not: The Potential for Urban Water Conservation in California (Gleick, et al., 2003) examines water conservation opportunities, including lower-flow showerheads in hotels and hospitals. Details used in the Pacific Institute's analysis were used in this analysis to develop commercial showerhead annual utilization estimates for hospitality and health-care applications (see Section 3.1.2).

APPENDIX F: CURRENT DEEMED SAVINGS FOR RESIDENTIAL LOW-FLOW SHOWERHEADS

The following tables summarize that data used to develop the current deemed savings estimates for residential low-flow showerheads, which were presented to the RTF in 2007. Table 17 states the input assumptions and savings estimates for showerheads, based on variety of studies. Table 18 states the water and sewer rates and population-weighted regional average cost per 1000 gallons of water, which is used to estimate non-energy benefits for cost-effectiveness calculations.

Table 17. Current deemed residential shower water and energy inputs and savings estimates

Energy Savings from Average Electric Water Heat Customer				
in Seattle City Light Service Area	Delta Water Flow from 2006 SCL/SBW Study			
Parameters	Average Seattle Household	Primary Showerhead Only	Secondary Showerhead Only	Average Program Participant
Per Household Annual kWh Electricity Savings	**201**	**172**	**88**	**144**
Households with Showerheads	*adjustable >*	***67%***	***33%***	***100%***
Delivered Showerheads Installed	90%	90%	90%	90%
Daily Showers per Person	0.64	0.55	0.28	0.46
Annualized Occupancy (days)	350	350	350	350
Persons per Household	2.51	2.51	2.51	2.51
Average Shower Length (min)	7.84	7.84	7.84	7.84
Delta Water Use Saved (gpm)	**0.40**	**0.40**	**0.40**	**0.40**
Shower Water from Hot Tap (%)	68%	68%	68%	68%
Delta Water Temperature Rise (tank outlet - inlet)	75	75	75	75
Heating Energy (Btu per degree F per gallon)	8.29	8.29	8.29	8.29
Electric Energy (1 kWh per 3413 Btu)	0.000293	0.000293	0.000293	0.000293
Steady State Heat Loss Factor	102%	102%	102%	102%
Per Household:				
Annual Gal. Water Savings	**1593**	**1364**	**694**	**1143**
Daily Gal. Water Savings	**4.55**	**3.90**	**1.98**	**3.27**

Table 18. Water and sewer costs by location and population-weighted average for Northwest region

City	Weight	Water	Sewer	Total/1000 Gal	Population
Boise	9%	$1.61	$1.76	$3.37	283,402
Portland	21%	$2.37	$7.53	$9.89	633,224
Seattle	54%	$4.48	$9.04	$13.52	1,664,846
Spokane	13%	$0.66	$1.43	$2.09	409,736
Missoula	3%	$1.92	$1.71	$3.63	89,344
Region	100%			$10.03	3,080,552

Adjust Water Heater Temp (120 Degrees) - Detailed Energy Savings		
Data Point	Quantity	Source
Gallons used/household/year (w/ new showerheads)	12,032	=8,031*1.5 GPM
Average temperature of heated water (Correct water temp)	122	"If you have a suppressed immune system or chronic respiratory disease, you may consider keeping your hot water tank at 140ºF": http://energy.gov/energysaver/projects/savings-project-lower-water-heating-temperature. We assume average temperature of 122.
Delta T	55	Now the water heater only needs to heat the water 55 degrees (from 67 to 122)
Therms/gallon heated (Correct water temp)	0.0076	= (1.0BTU/lb*degree F)*(1 Therm/99.976 BTU)*(8.34 lbs/1 gallon)*(55 degrees F)/0.60
Therms saved/gallon heated from water temperature correction	0.0011	n/a
Therms saved/household/year from water tempertaure correction	**13.38**	**=0.0011*12,032**

- ABOUT ENERGY STAR
- PARTNER RESOURCES

Refrigerator Retirement Savings Calculator

19.0-21.4 Cubic Feet
Top Freezer

$0.11

$142.64

1,285 kWh

Say goodbye to your old refrigerator or freezer and you can save $715 over 5 years.

Your model costs...

$143 per year to run

Go Compact! If you need a second refrigerator or freezer, pick an ENERGY STAR qualified model and save.

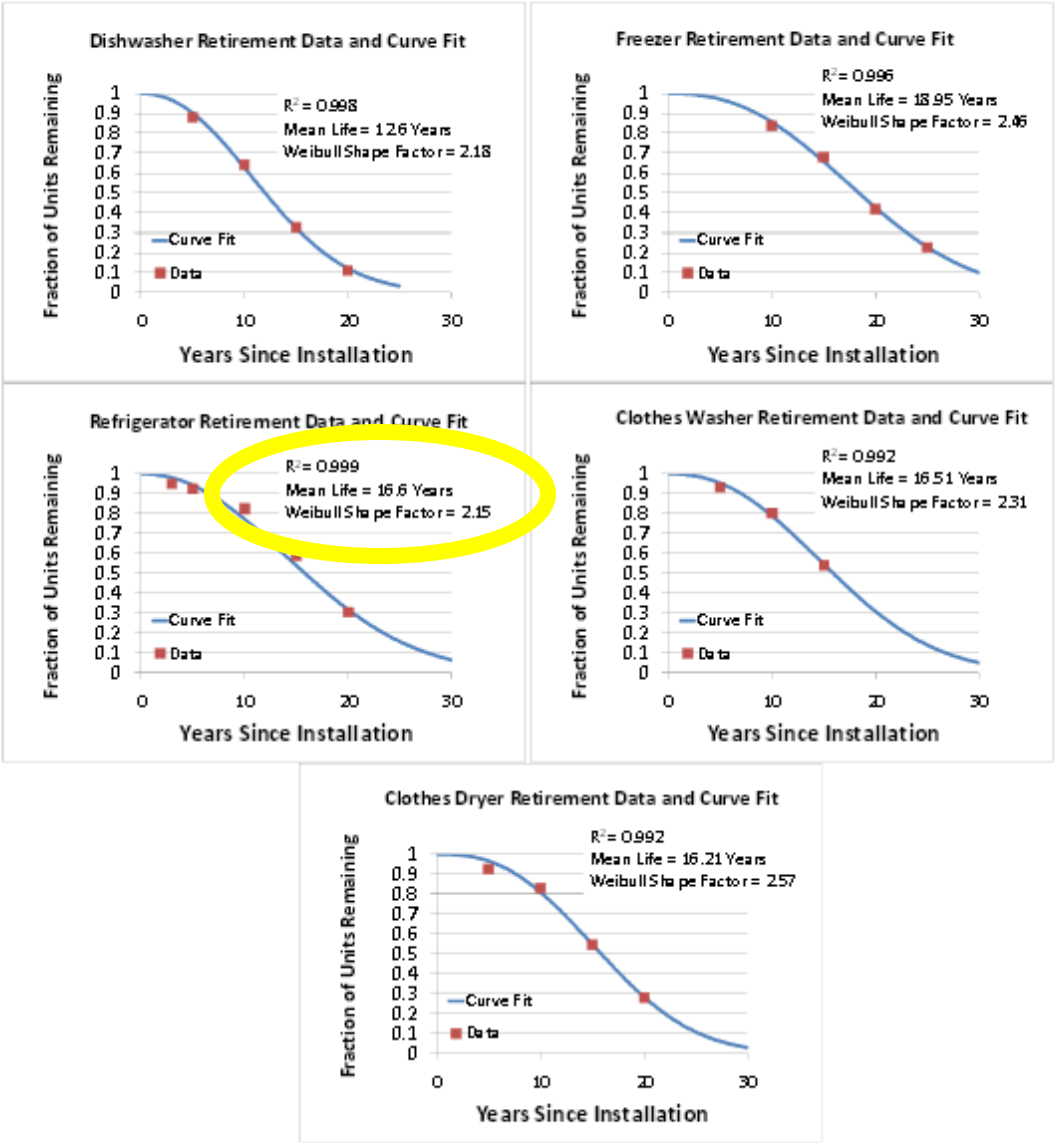
Find Out How

Note: If your refrigerator or freezer is a newer, ENERGY STAR qualified model your results may not display significant savings.

This Refrigerator Retirement Calculator is designed to provide an estimate of the savings associated with replacing or removing an old refrigerator or freezer with a new ENERGY STAR certified model. Actual savings may vary based on use, upkeep, and other factors. Assumptions are based on a combination of historical data (adjusted for degradation based on the age of the refrigerator/freezers) and calculations cited in the ENERGY STAR specifications.

If you have trouble using this tool, please contact appliances@energystar.gov

Figure 3. Curve-Fit of Appliance Mortality Data using a Weibull Distribution



As seen in Figure 3, the Weibull distribution appears to be a good choice curve-fitting to appliance retirement data. The data were then normalized by mean lifetime to illustrate the similarity in the *shape factor* of the mortality curves across these appliances. Figure 4 shows that appliance mortality behaves in a very consistent manner across multiple residential appliances, when normalized by mean lifetime.

Document 5

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EXPERT APPLIANCE REPAIR

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Appliance Life Expectancy

Do you know how long your freezer will last? How many years should you expect your washer and dryer to function properly? To effectively manage your household budget, it helps to know the life expectancy of your appliances. This can help you determine if an appliance can be saved or if its time might be up. The best way to ensure your appliances have a long, healthy life is to perform regular maintenance and have them checked periodically by an appliance repair expert.

Major Home Appliances (Excludes Commercial Appliances)

Life Expectancy (Years)

	Low	High	Average
Trash Compactors	7	12	11
Dryers, electric	11	18	14
Dryers, gas	11	16	13
Dishwashers	9	16	12
Garbage Disposals	10	15	13
Freezers	12	20	16
Microwaves	5	10	8
Ranges, electric	13	20	16
Ranges, gas	15	23	19

Ranges, hoods	9	19	14
Refrigerators, compact	4	12	8
Refrigerators, standard	10	18	14
Washers	8	16	12

Life expectancy of appliances as reported in the 23rd annual portrait of the U.S. appliance industry.

Regular maintenance can help extend your appliance's lifetime; however, it can come to a point where it would be advisable to replace your appliance rather than repair it. Has your appliance reached its life expectancy? Call us today to schedule an appointment or use our simple Service on your Schedule form here!

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Document 6

APPENDIX

A.

SUGGESTED USEFUL LIVES

OF

FIXED ASSETS

APPENDIX A
Useful Lives

SUGGESTED USEFUL LIVES

Appendix A offers suggested useful lives for various types of depreciable assets. Use of these estimates is not required. They are presented to aid those districts which have not recorded depreciation in the past, but are now required by the uniform accounting systems to do so. Districts which through experience have developed satisfactory depreciation rates should continue to use them.

The basis for depreciation, definitions and suggestions for the first-time valuation of assets are given in Appendix B - "Accounting for General Fixed Assets", Parts I and II. Parts III and IV of Appendix B are not applicable to utility-type districts, but apply to districts subject to 9000 - Other Districts, in which depreciation is not recorded.

Assets and their estimated lives are presented by type of district:

1000 - General
2000 - Water Utility
3000 - Harbor & Port
4000 - Airport
5000 - Transit
6000 - Hospital
7000 - Electric Utility
8000 - Waste Disposal

Under "General" are items which might be used in any district, such as tables, adding machines, etc. The other categories contain assets which are probably unique to the type of district indicated, although there could be exceptions. For example, ambulances, while listed under 6000 - Hospital, might be owned by an airport district.

Some districts may prefer to group certain assets and depreciate the group on a composite life basis. The listings include estimates for some such groups.

The schedules which follow can never completely catalog all items which might be found in California's thousands of special districts. For assets not included, some asset with enough similarity to serve as a guide can probably be found.

1000. GENERAL

Accounting machines	8
Adding machines	10
Addressographs	15
Agricultural equipment	22
Air conditioners (window)	10
Air conditioning systems:	
Over 20 tons	15
5-15 tons	12
Under 5 tons	8
Aluminum ware	22
Amplifiers	5
Antenna systems	6
Anvils	15
Apartments	50
Automobiles	4
Balances	15

APPENDIX A
Useful Lives

GENERAL

Bath houses:	
Brick, concrete, masonry	33
Wood	20
Benches	20
Bins	20
Blacksmith shop equipment	20
Boats:	
Power	15
Row	10
Boilers	20
Bookkeeping machines	8
Broilers	10
Buffer, electric	10
Building & structures	30
Bulldozers	8
Business machines	15
Cabinets	15
Cables	4
Calculators	10
Cameras	5
Carpets	8
Carrousels	15
Cash registers	10
Casket lowering devices	5
Caterpillars	8
Cattle	8
Cement gun machines	4
Cemetery roads	50
Cesspools	15
Chairs	15
Chapels	50
Check protectors	10
Cisterns	33
Clock systems	15
Coaster dips (amusement)	15
Collators, electric	12
Communication systems	25
Compressors	12
Concrete mixers:	
Electric, gas	5
Steam	8
Conduits (underground)	70
Conveyor systems	15
Cookers, pressure	10
Coolers, walk-in	20
Copy machines	8
Cranes	30
Cremation retorts	25
Creosoting plants	22
Culverts:	
Galvanized iron	25
Masonry	50
Cutters	10
Desks	15
Dictating equipment	8
Dish sterilizers	10
Dishwashers	10
Ditto machines	10
Draperies	8
Dryers:	
Clothes	15
Hair	10
Drill presses	15
Dwellings	60
Electric transcribers	5
Elevators	20
Embalming equipment	10
Emory wheels	15
Extractors, laundry	15
Factory buildings	50
Fans, ventilating	12
Farm buildings	60
Fences:	
Chain link, wood	15
Brick, stone	35
Iron	30
File cabinets	15
Firearms	20
Fire boxes	10
Fire extinguishers	3
Fire protection systems	20
Flagpoles	20
Floor waxing, scrubbing machines	7
Folders (laundry)	15
Food choppers	12
Frames, turning	15
Fryers, deep fat	10
Fumigators	10
Garages	60
Goats	5
Graders	17
Grain elevators	75
Grandstands:	
Concrete, steel	30
Wood	15
Grave coverings	5
Grease pumps	3

APPENDIX A
Useful Lives

GENERAL

Green houses	25
Griddles	10
Grinders:	
Bench	15
Coffee	10
Hardware	25
Harnesses	10
Heaters:	
Electric	12
Gas	15
Heating systems	20
Helmets, diving suits	10
Hogs	5
Hoists	20
Horses	10
Hoses:	
Fire	5
Garden	15
Ice cream freezers	10
Ice cream storage cabinets	10
Ice cube making equipment	10
Ice plant	22
Ice & refrigeration equipment	18
Impact wrench	10
Incinerator	10
Incubators, brooders	15
Ironers	15
Jackhammers	3
Jointers, planers, electric	15
Kettles, steam jacketed	10
Kilns	10
Ladders	10
Lathes	20
Lawn mowers, power	3
Loaf molding equipment	10
Lockers, steel	12
Loft buildings	67
Logging machinery & equipment	10
Looms	15
Lumber remanufacturing plants	20
Machine shops	60
Machine tools	18
Mailing machines	12
Mangles	12
Marking machines	15
Mausoleums	50
Meat choppers	10
Microfilm units	15
Microphones	7
Microprojectors	20
Milking machines	20
Milling machines	15
Mirrors	20
Mixers:	
Food	15
Concrete	12
Motion picture projectors	10
Motors, AC & DC:	
Small	8
Medium	10
Large	12
Mowers, electric trimmer	3
Mules	10
Nailing machines	20
Office buildings	67
Office equipment	20
Office funiture & fixtures	15
Oil tanks	35
Organs	15
Ovens, baking & roasting	15
Paint spray booths	15
Paint spraying equipment	12
Paper balers	20
Pavilions:	
Fireproof	40
Frame	30
Paving:	
Asphalt	10
Concrete	15
Gravel	5
Peelers - potato, vegetable	15
Pianos	12
Picking machines	5
Piers	33
Pipe	20
Planers & shapers, electric:	
Metal	15
Wood	20
Plows	15
Plumbing	20
Poles (telephone)	26

APPENDIX A
Useful Lives

GENERAL

Polishers, buffers	10
Pools, swimming	20
Portable sawmills & equipment	10
Presses:	
Shop	20
Laundry	15
Projection machines	15
Radios, two-way	8
Radio towers & masts	15
Railroad equipment	25
Refrigerators	12
Restaurant furniture & fixtures	12
Riveters	4
Roofs:	
Tar & gravel	20
Asbestos	25
Asphalt & tar	15
Galvanized iron:	
Hot dipped	20
Cold dipped	15
Rugs	10
Saddles	10
Safes	35
Saws:	
Band	10
Bench	15
Sawmill machinery & equipment	25
Scales:	
Counter, platform, postal	10
Laundry	20
Scooters	15
Separators, cream & grain	15
Sewer & water lines, underground	20
Sewing machines	10
Shaking machines	10
Shears, squaring & floor	20
Sheep	5
Ships	25
Shovels:	
Electric	20
Steam	25
Shrubs, lawns, trees	10
Signs	12
Silverware	5
Skill saws	3
Slicers, bread & meat	10
Slides, playground	15
Smudge pots	10
Snow blowers	10
Splicers, film	15
Steam cleaners	10
Steamers, vegetable	10
Stenorettes	5
Steropticons	15
Stoves:	
Cooking	15
Heating	10
Suction pumps	10
Tables	15
Tarpaulins	8
Telephone systems	20
Television central antenna systems	10
Tents	5
Thermometers	5
Thermometers, recording	20
Threshing machines	15
Time recording equipment	10
Toasters, commercial type	8
Tractors	8
Transcribing equipment	10
Transmission machinery	15
Transverters	15
Trees & vines:	
Almond, grapefruit, lemon, orange, pear, walnut	40
Apple, cherry, olive	50
Apricot	25
Fig	60
Plum, prune	33
Peach	15
Banana	10
Trucks, hand	20
Trucks, heavy	10
Trucks, lift	15
Trucks, pick-up	5
Typewriters	5
Urns - coffee, milk	12
Vacuum cleaners	10
Vacuum cleaning systems	20
Vats, dipping	10
Ventilating fans	15
Vises	5
Waffle irons, commercial-type	15
Warehouses	75
Washing machines	15
Water coolers - bottle, fountain	10

APPENDIX A
Useful Lives

GENERAL

Water heaters	20
Water purifiers & softeners	15
Welders - arc, acetylene	10
Wells, well pumps	25
Wheelbarrows	2
Wiring:	
Inside	25
Outside	15
Wrapping machines	15
Yard lighting	20

2000. WATER UTILITY

Accessory dam equipment	33
Bridges	20
Bridges, railroad	33
Canal linings	100
Cement pipe plant	25
Chlorinators	12
Coagulating basins	50
Collecting conduits	75
Dams, structures & improvements	33
Dams, impounding	100
Diesel engines	25
Drains	100
Filters	50
Flumes	50
Gates	50
General Plant:	
Structures & improvements	40
Office furniture & equipment	12
Transportation equipment	12
Stores equipment	15
Laboratory equipment	15
Power operated equipment	15
Tools, shop & garage equipment	20
Houses, ditchtender	20
Hydrants	40
Infiltration galleries	100
Mains, cast iron:	
4" or less	50
8-10"	75
6"	65
12" or over	100
Meters	30
Pumping plant:	
Structures & improvements	40
Pumping equipment	25
Other pumping plant	20
Pumps	50
Railroads	33
Reservoirs	100
Roads	33
Settling basins	50
Siphons	20
Source of supply plant:	
Structures & improvements	40
Collecting & impounding reservoirs	100
Lakes, rivers & other intakes	50
Wells	30
Supply Mains	60
Spillways	25
Springs	100
Stand pipes	50
Steam engines	30
Transmission & distribution plant:	
Structures & improvements	40
Reservoirs & tanks	60
Mains:	
Cast iron, asbestos, cement	75
All other	40
Services	30
Meters	30
Meter installations	35
Hydrants	40
Other plant	25
Tunnels	100
Water measuring devices	110
Water treatment plant:	
Structures & Improvements	40
Water treatment equipment	30

APPENDIX A
Useful Lives

WATER UTILITY

Weirs	50
Wells - irrigation & drainage	30

3000. HARBOR & PORT

Barges:	
Steel	30
Wood	25
Boats:	
Hoist or derrick	20
Hull	33
Docks	25
Dories	10
Dredges:	
Steel hull	30
Wood hull	30
Elevators - floating, grain	40
Ferryboats	40
Hoists	25
Launches	33
Lighters:	
Steel	30
Wood	25
Motor vessels - diesel, ocean	33
Nets, fishing:	
Gill	4
Trap	5
Paving (Pier)	20
Piers, minor	25
Pilings	10
Pontoons, steel	33
Rowboats	10
Scows:	
Steel	30
Wood	25
Steam vessels:	
Coastal	38
Ocean	33
Oil tankers	30
Passenger, freight	40
Excursion	50
Tugs - gas, oil	30
Tugs, steam	40

4000. AIRPORT

Aircraft	5
Buildings:	
Fireproof	40
Frame	20
Communication equipment	4
Communication equipment, airway	6
Engines, aircraft	6,000 hrs
Fuel storage & distribution equipment	10
Hangar equipment	10
Lighting equipment, airport & airway	15
Propellers:	
Regular	2,000 hrs
Full-feathering	4,000 hrs
Shop equipment	10

APPENDIX A
Useful Lives

5000. TRANSIT

Ballast	50
Bridges, trestles, culverts	45
Busses, diesel:	
Street use	15
Charter	7
Urban	10
Interurban	8
Trolley	15
Bus equipment	15
Conduits, underground	60
Crossings	25
Fences	25
Grading	50
Locomotives, electric	35
Moguls	12
Passenger cars	35
Rails, fastenings, joints	28
Shelters, passenger	15
Shops & car houses	55
Signals & interlocking apparatus	25
Signs	25
Stations & structures	50
Substation buildings	45
Substation equipment	25
Ties	28

6000. HOSPITALS

Analyzers, gas	10
Ambulances	4
Anesthesia units	15
Audiometers	10
Auto-analyzers	10
Autoclaves	15
Autoscalers, ionic	10
Bain maries	15
Basal metabolism units	10
Bassinets, heated	10
Baths	15
Beds	15
Biochemical analysis units, micro	10
Blanket dryers	15
Blanket warmers	15
Bleach tanks	15
Blood clot timer units	15
Blood counters	15
Blood processing units	10
Boiler houses	30
Bottle washers	10
Breathing units	10
Cabinets, solution	15
Cardiographs	10
Carts, food	10
Cassette changers	15
Centrifuges	15
Chairs - dental, specialist, steel	15
Chloridometer, titrators	12
Chromatographs, gas	10
Cobalts, radioactive	5
Coldpack units, floor	12
Collectors - silver, automatic	15
Colorimeters	10
Condensate tanks	20
Condensers	15
Coolers, dehumidifiers	15
Counters, radiation	10
Croupettes	10
Crushers, syringe	10
Defibrillators	10
Diathermy units	10
Disinfectors	15
Distilling apparatus	20
Driers, sonic	10
Electrocardiographs	10
Electroencephalographs	10
Electrosurgical units	10
Examining tables	15
Fluoroscopes	10
Furnaces, laboratory	20
Garages:	
Masonry	25
Wood frame	15
Generator sets	25
Glove conditioners, driers, powdering machines, testers	10

APPENDIX A
Useful Lives

HOSPITALS

Graphotypes	15
Heaters	15
High frequency apparatus with diathermy	10
Homogenizers	15
Hospital buildings - masonry, steel or reinforced concrete frame	40
Hospital buildings - wood frame	30
Hubbard tanks	15
Hydrocollators, floor	12
Illuminator units, multi-film	15
Incubators, laboratory	15
Kymographs	10
Lamps:	
Deep therapy, infrared mercury quartz	10
Emergency	15
Lights:	
Delivery, operating	15
Examining	10
Portable emergency	20
Linen markers	15
Linen table	15
Meters, pH	10
Microscopes	15
Nurse call systems	20
Oil storage tanks	20
Oscilloscopes	15
Ovens - paraffin, sterilizing	10
Oxygen, air piping	20
Oxygen tents, motors & trucks	10
Paging systems	15
Photometers	10
Physicians in-and-out registers	15
Pulmotors	10
Pumps - vacuum, pressure	15
Radiographic-fluoroscopic combinations	10
Residences:	
Masonry	30
Frame	25
Respirators	10
Respirometers	10
Resuscitators	10
Rinsers, sonic	10
Scanners, isotope	10
Scintillation scalers	10
Seriographs, automatic	10
Serological baths	15
Sharpeners, microtome knife	15
Spectrometers	10
Spectrophotometers	10
Sterilizers	20
Storage buildings	20
Tables:	
Autopsy, obstetrical, operating	20
Examining, therapy	15
Refrigerated	12
Tanks - hot water, paraffin, soap	15
Tents, oxygen	10
Tissue processors	10
Tray conveyors	15
Trucks, hot food	10
Tumblers	15
Ultraviolet units	15
Vibrators	10
Volumetric apparatus	10
Warmers - dish, food	15
Water baths	15
Whirlpool baths	15
X-ray:	
Developing tanks, film dryers, film processors, deep therapy, mobile machines, superficial therapy machines	10

APPENDIX A
Useful Lives

Hospital Groups

Administration	18
Anesthesiology	16
Central services & supply	15
Clinics	15
Delivery & labor rooms	20
Dietary	12
Emergency service	17
Employee health service	17
Fiscal services	15
General services	14

HOSPITAL

House staff quarters	18
Housekeeping	10
Laboratories	12
Laundry & linen	15
Maintenance of plant	15
Medical library	20
Medical records	18
Occupational therapy	15
Operating room	20
Operation of plant	20
Patient care units	18
Personnel quarters	18
Pharmacy	18
Physical therapy	10
Physicians' offices	17
Radiology	17
Recreational therapy	15
Retail shops	12
School of nursing	16
Social services	20
Student residences	18

7000. ELECTRIC UTILITY

Steam production:	
Structures & improvements	50
Boiler plant equipment	35
Turbogenerator units	40
Accessory electric equipment	35
Miscellaneous power plant equipment	25
Engines & engine driven generators	20
Hydraulic production:	
Structures & improvements	60
Reservoirs, dams & waterways	100
Water wheels, turbines & generators	35
Miscellaneous power plant equipment	35
Roads, railroads & bridges	60
Accessory electric equipment	35
Other production:	
Structures & improvements	45
Fuel holders, producers & accessories	20
Prime movers	20
Generators	20
Accessory electrical equipment	20
Miscellaneous power plant equipment	20
Transmission plant:	
Structures & improvements	45
Station equipment	30
Towers & fixtures	45
Overhead conductors & devices	40
Underground conduit	45
Underground conductors & devices	30
Roads & trails	60
Production plant:	
Structures & improvements	45
Station equipment	30
Poles, towers, fixtures	40
Overhead conductors & devices	30

APPENDIX A
Useful Lives

ELECTRIC UTILITY

Underground conduit	45
Underground conductors & devices	30
Line transformers	30
Services	30
Meters	30
Storage battery equipment	20
Installations on customer's premises	25
Street Lights & signal systems	25

General plant:	
Structures & improvements	50
Office furniture & equipment	20
Transportation equipment	10
Store equipment	20
Tools & shop equipment	20
Laboratory equipment	25
Communication equipment	20
Miscellaneous equipment	20

8000. WASTE DISPOSAL

Aeration systems	15
Centrifuges	10
Chlorinators	12
Clarifiers:	
Circular	25
Rectangular	15
Filters, vacuum	15
Incinerators - screening, sludge	15
Kilns	15
Manholes	50

Meters, metering vaults	50
Motors	20
Outfall sewer lines	75
Pumps, centrifugal	15
Screens, rotary	15
Structures - sewage disposal & treatment plant	40
Trunk lines - concrete, clay, cast iron, abestos, cement	50

Document 7

Expected Useful Life Summary

Device	Low	High	Average
Trash Compactors	7	12	11
Dryers, electric	11	18	14
Dryers, gas	11	16	13
Dishwashers	9	16	12
Garbage Disposals	10	15	13
Freezers	12	20	16
Microwaves	5	10	8
Ranges, electric	13	20	16
Ranges, gas	15	23	19
Ranges, hoods	9	19	14
Refrigerators, compact	4	12	8
Refrigerators, standard	10	18	14
Washers	8	16	12
Water Heater*	n/a	n/a	20
Air Conditioner*	n/a	n/a	15
Total			14

*From Suggested Useful Life of Fixed Assests from California State Controllers Office included in Document 6. All other items from Mr. Appliance document included in Document 5.

Document 8

5.4 Water Resource Optimization

Arlington Desalter (WMWD)
Riverside, CA

Recommendations

Based on the data from 2010 Urban Water Management Plans (UWMPs), the Santa Ana River Watershed is able to meet its demands in the average, single-year drought and multi-year drought scenarios while maintaining a reliability margin of 10%, or greater, to help offset future unknowns. The UWMPs assume that:

1. Future local precipitation patterns will be the same as past precipitation patterns (possible effects of climate change addressed later in the Chapter)
2. The predicted reliability of the State Water Project as taken from the Department of Water Resources (DWR) *The State Water Project Delivery Reliability Report 2009* (August 2010) is accurate
3. Imported water projections include possible effects of climate change
4. Imported water will be managed to store wet year supply for use during dry years
5. Future demands will match the estimated demand
6. The watershed will invest over $4 billion in water conservation and infrastructure projects
7. Significant investments will be made to improve the reliability of imported water supplies as detailed in Metropolitan Water District of Southern California's (MWDSC) 2010 Regional UWMP

Given the uncertainty in these assumptions, it is recommended that the Santa Ana River Watershed focus on the implementation of water management concepts marked with a ☑ over the next five years to achieve water supply reliability over the broadest area of the watershed at the most reasonable cost. Each of these concepts is described in more detail in the **Water Management Strategies and Watershed-wide Project/Program Concepts to Improve Water Supply Reliability** section of the Chapter.

Summary of Water Management Strategies and Watershed-wide Project/Program Concepts to Improve Water Supply Reliability

(☑ indicates a concept recommended for focus during the next planning cycle)

	Strategy Concept (in no particular order)	Status	Estimated Benefit
REDUCE DEMAND			
☑	Water rate structures that encourage conservation	Widely implemented	Help meet SBX7-7 required demand reductions
☑	Public education to encourage water conservation	Widely implemented	Help meet SBX7-7 required demand reductions
	Outdoor conservation	Widely implemented	Help meet SBX7-7 required demand reductions
	Reduce evapotranspiration	Conceptual	More investigation required
OPTIMIZE IMPORTED WATER			
	Wet year storage program	In process	Increases storage in watershed
☑	Bay Delta Conservation Plan[1]	In process	$730{,}000 \times 0.18 = 131{,}400$ Acre Feet per Year (AFY) and improved water quality
	Imported water banking	Widely implemented	Water in dry years
	Prevent invasive species from clogging infrastructure	In process	Consistent deliveries
STORMWATER CAPTURE			
☑	Enhanced Santa Ana River stormwater	In process	12,000 AFY
☑	Enhanced stormwater capture from tributaries of Santa Ana River	In process	28,000 AFY
☑	Riverside North Aquifer Storage and Recovery Project	In process	12,800 AFY
☑	Enhanced Santa Ana River stormwater capture at Prado Dam	Conceptual	10,000 AFY
☑	MS4 Credits	Conceptual	Increased stormwater capture
☑	Re-operate flood control facilities	In process	More investigation required
☑	Size flood control facilities for stormwater capture	Conceptual	Increased stormwater capture
☑	Forest First: Forest management for increased downstream stormwater capture	In process	Increased stormwater capture

[1] Assume average maximum entitlement for the State Water Project (SWP) increases from 60% to 78%.

	Development Standards that enhance stormwater capture	Conceptual	Increased stormwater capture
RECYCLE WATER			
☑	Recycled water exchange	Conceptual	Capital and energy savings ($100s millions), improved water quality
☑	Recycled water for potable use	Conceptual	More investigation required
	Recycle wastewater flowing to the ocean	In process	157,000 AFY
	Import recycled water from outside the watershed	Conceptual	More investigation
	Ocean Desalination[2]		54,000 AFY
	Recycled water use to offset potable demand	In process	This is widely implemented by several agencies and part of the projected water supply portfolio
INCREASE STORAGE			
☑	Surface Water Storage	In process	Helps offset drought and climate change
☑	Groundwater storage	In process	Helps offset drought and climate change
IMPLEMENT EMERGENCY MEASURES			
	Emergency Measures	In process	Preparation for catastrophic event
	Total		**405,200 AFY**

The climate and geography of the State of California present a unique challenge to the management and delivery of water. While most of the precipitation falls on the northern portion of the State, most of California's population resides in the semi-arid, southern portion of the State. Water is diverted, stored, and then transferred from the water-rich north when needed to the more arid central and southern sections of the state through the California State Water Project (SWP), the Central Valley Project (CVP), and the Los Angeles Aqueduct.

In addition to the projects that transport water from the north to the south, the southern coastal area relies on water imported through MWDSC's Colorado River Aqueduct (CRA). The U.S. Bureau of Reclamation and seven basin states manage the Colorado River (CR) system under the authority of the Secretary of the Interior and for the benefit of seven "basin states". California's share of the CR Supply is 4.4 million acre-feet (maf).

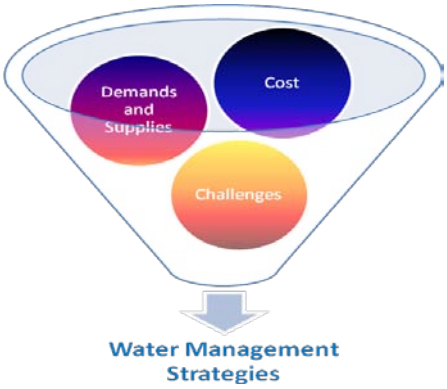
During most years the supply available to the region has been adequate for its needs. The region has gotten through the drier years by using water that was stored during wetter years.

[2]Poseidon Huntington Beach Ocean Water Desalination, 50 million gallons per day.

Even though the State's water supply is more than adequate for its population and economic needs, the laws of the State and Federal governments have allocated the majority of that supply for environmental purposes and made building new surface storage increasingly difficult and expensive. This has forced Californians to seek more creative and sustainable and often more expensive solutions to water resource management wherever possible.

The Santa Ana River Watershed lies in semi-arid Southern California. Like many other areas, the watershed is carefully evaluating water supplies and demands and seeking creative, cost-effective strategies to provide a reliable water supply into the future. Water supply reliability in Southern California will be challenged by multi-year droughts, droughts on the CR, limited local water resources, the vulnerability of the Sacramento-San Joaquin River Bay-Delta, and the threat of climate change. In addition, vulnerabilities in regional and statewide infrastructure could increase due to major seismic events. Designing a diverse and flexible water resource management system that can meet these challenges will help to ensure water reliability and a sustainable and vibrant economy for the Watershed.

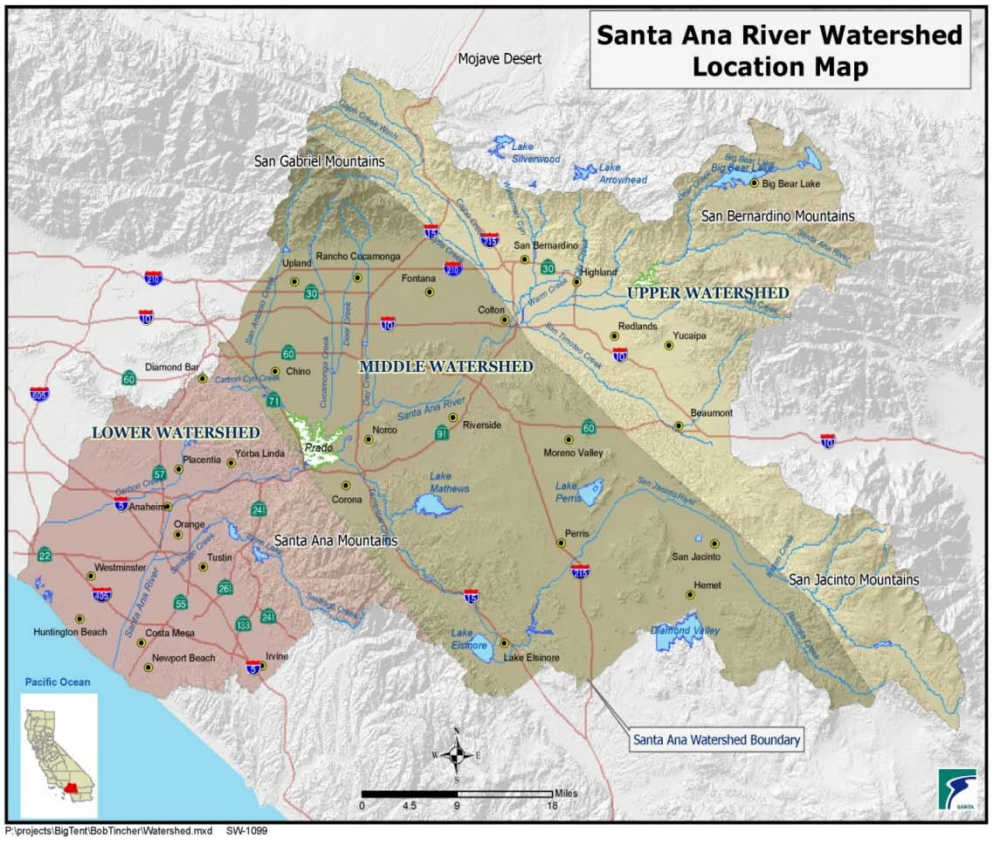
The One Water One Watershed (OWOW) collaborative process has facilitated the discussion of water management and sustainability throughout the Watershed. The key objective for water supply reliability is a cost-effective and diverse water supply and water storage portfolio that makes better use of existing facilities and supplies; improves overall water use efficiency; achieves a practical level of inter-connections and redundancy; and optimizes water storage for use during drought periods. This section of the plan focuses on how to maintain a robust and reliable water supply within the watershed.



Current Conditions

There are five principal wholesale agencies that form the Santa Ana Watershed Project Authority (SAWPA) and manage most of the water supplies within the watershed, both local and imported. In addition to these regional water agencies, the watershed also contains portions of four counties represented, as well as retail and wholesale water agencies. For purposes of this report, the analysis has been organized by three general areas: upper watershed, middle watershed, and lower watershed. These areas are subsets of the Santa Ana River Watershed (**Figure 5.4-1**). The regional water agencies within each general area are described below.

Figure 5.4-1 Watershed Areas



Upper Watershed

San Bernardino Valley Municipal Water District (Valley District) is a State Water Contractor and provides imported water from the SWP to local retail agencies in its 325 square mile service area to supplement and enhance groundwater resources. Valley District's service area generally includes the cities and communities of San Bernardino, Colton, Loma Linda, Redlands, Rialto, Bloomington, Highland, Grand Terrace, and Yucaipa. Valley District is a member agency of SAWPA.

San Gorgonio Pass Water Agency (SGPWA) is a State Water Contractor, and provides imported water from the SWP to local retail agencies in its 225 square mile service area to supplement and enhance groundwater resources. SGPWA's Service area includes Calimesa, Beaumont, Banning, Cherry Valley, Cabazon, and Morongo Indian Reservation. The SGPWA service area straddles the Watershed, with its western two-thirds in the watershed and eastern one-third in the Whitewater River watershed.

Middle Watershed

Eastern Municipal Water District (EMWD) is a member agency of MWDSC and provides both water and sewer service throughout its 555 square mile service area. Major communities include Moreno Valley, Hemet, San Jacinto, Perris, Sun City, Menifee, Winchester, and parts of Temecula, and Murrieta. In addition to retail customers, EMWD wholesales water through seven local water agencies. EMWD is a member agency of SAWPA.

Western Municipal Water District (WMWD) is a member agency of MWDSC and provides water service throughout its 510 square mile service area in western Riverside County. Within its boundaries lie the communities of Jurupa, Rubidoux, Riverside, Norco, Corona, Elsinore Valley, and parts of Temecula. WMWD serves imported water directly to customers who are located in the unincorporated and non-water bearing areas around Lake Mathews and portions of the City of Riverside. Ten wholesale customers are served by WMWD with both CR and SWP water. WMWD is a member agency of SAWPA.

Inland Empire Utilities Agency (IEUA) is a member agency of MWDSC and provides water and sewer services to a 242 square mile area in the western portion of San Bernardino County. Within its boundaries lie the Cities of Chino, Chino Hills, Fontana, Montclair, Ontario, Rancho Cucamonga, and Upland. IEUA is a member agency of SAWPA. Also, the majority of the IEUA service area overlies the Chino Basin Watermaster boundary.

Chino Basin Watermaster (Watermaster) is a consensus-based organization facilitating the development and utilization of the Chino Groundwater Basin. The Watermaster consists of various entities pumping water from the Basin including cities, water districts, water companies, agricultural, commercial, and other private concerns. The Watermaster's mission is "to manage the Chino Groundwater Basin in the most beneficial manner and to equitably administer and enforce the provisions of the Chino Basin Watermaster Judgment", Case No. RCV 51010 (formerly Case No. SCV 164327).

Lower Watershed

Orange County Water District (OCWD) manages groundwater within its 355 square mile service area. Within its boundaries lie the Cities of Anaheim, Buena Park, Costa Mesa, Fountain Valley, Fullerton, Garden Grove, Huntington Beach, Irvine, La Palma, Los Alamitos, Newport Beach, Orange, Placentia, Santa Ana, Seal Beach, Stanton, Tustin, Villa Park, Westminster, and Yorba Linda. OCWD recharges the groundwater basin with surface water flows from the Santa Ana River and Santiago Creek, recycled water from the OCWD Groundwater Replenishment System (GWRS), and imported water which is purchased from the Municipal Water District of Orange County. OCWD is a member agency of SAWPA.

Municipal Water District of Orange County (MWDOC) is a member agency of MWDSC and sells imported water to 29 retail water agencies and cities in north and south Orange County. MWDOC also sells water to OCWD. MWDOC also straddles the Watershed, with its northernmost portion being in the Watershed and its southern portion being outside of the watershed.

Within each of these regional agencies, there are a number of retail water agencies. For purposes of brevity, these local agencies have not been individually listed in this report. However, these agencies did provide invaluable input into the OWOW process.

Water Sources

The Watershed gets about 50% of its water from local precipitation in the form of surface water and stored as groundwater. The Watershed imports about 30% of its water from the SWP and Colorado

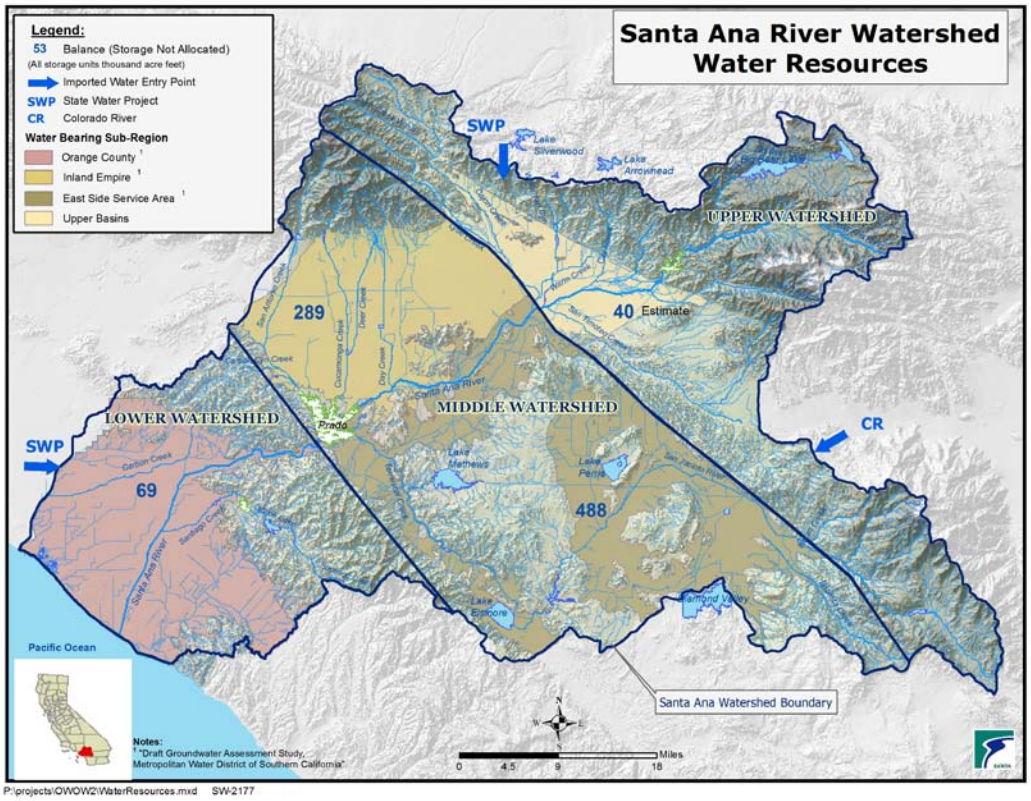
River. The remaining 20% of the Watershed's water supply is recycled water. Each of these sources are explored below.

Precipitation Stored as Groundwater

The underground pore space between soil granules provides a location to store water, referred to as groundwater, which can be later extracted using wells. To avoid double-counting water supplies, OWOW 2.0 limits the term groundwater to precipitation stored as groundwater. Imported water stored in the ground is classified as "imported water". The watershed's underground storage space functions essentially like a series of underground reservoirs. These underground reservoirs, or basins, range from a few hundred to over one thousand feet in thickness. Basins upstream from Prado Dam underlie about 1,200 square miles of the watershed, while basins downstream from Prado Dam underlie about 400 square miles of the watershed. Yields of nearly all of the basins within the watershed have been estimated using past hydrology and, for planning purposes, agencies have assumed that this past hydrology will continue to repeat itself and does not include any possible effects from climate change. Possible water resource effects from climate change are addressed later in this chapter and the possible overall effects of climate change are addressed in **Chapter 5.13 Energy and Environmental Impact Response**. Recognizing that hydrological patterns are expected to be altered due to climate change with subsequent impacts to demand and supplies, climate change impacts are discussed and addressed later in this chapter. Basin's safe yield is the amount of water that can be annually pumped from a basin on a permanent basis without emptying the basin.

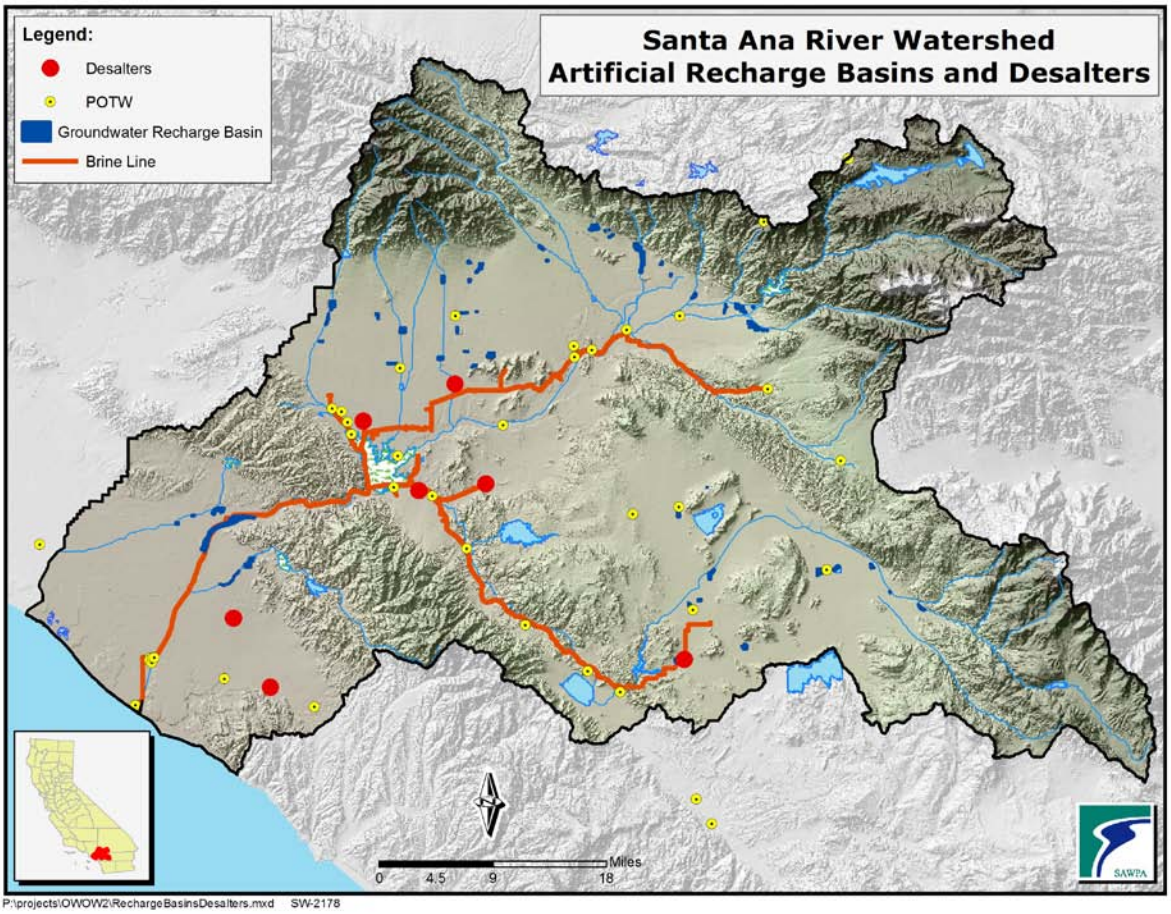
In general, the watershed relies on precipitation stored as groundwater to provide about 50% of the water supply. **Figure 5.4-2** generally shows the larger groundwater basins within the watershed along with any available storage capacity (individual basins and sub-basins have been omitted for clarity). These basins provide storage space for local and imported water supplies that can be used during droughts or other shortages. The amount of storage space in the lower watershed is based on the storage volume that could be available in approximately eight out of ten years.

Figure 5.4-2 Groundwater Resources within the Watershed (Thousand acre-feet)



Artificial replenishment involves storing additional water in the basin(s), over and above precipitation stored as groundwater. The most common type of artificial replenishment is “spreading” water into open “pits”, or basins, and allowing it to soak into the ground down to the “water table”. Another commonly used method is called “in-lieu” replenishment. This method involves replacing groundwater with another source of water. This corresponding reduction in groundwater pumping results in less water being removed from the basin which effectively acts to replenish the groundwater supply. Finally, the most costly method of artificial replenishment is to inject the water into the basin using an injection well(s). Of the various methods available, artificial recharge the most common throughout the Watershed. **Figure 5.4-3** shows the locations of spreading basins in the watershed.

Figure 5.4-3 Artificial Recharge Basins and Desalters



One challenge to groundwater supplies in the watershed is poor water quality, typically due to total dissolved solids (TDS or salinity) and nitrates. These salts accumulate mostly through use and evaporation, but also are introduced to the water supply by way of agricultural fertilizers and septic tanks. Further, there are numerous forms of contamination found in the watershed, such as; TCE, PCE (commonly used solvents) and Perchlorate (fertilizer, fireworks and explosives). All these forms of contamination must be removed using various treatment methods before it can be introduced into the water supply system.

Precipitation as Surface Water

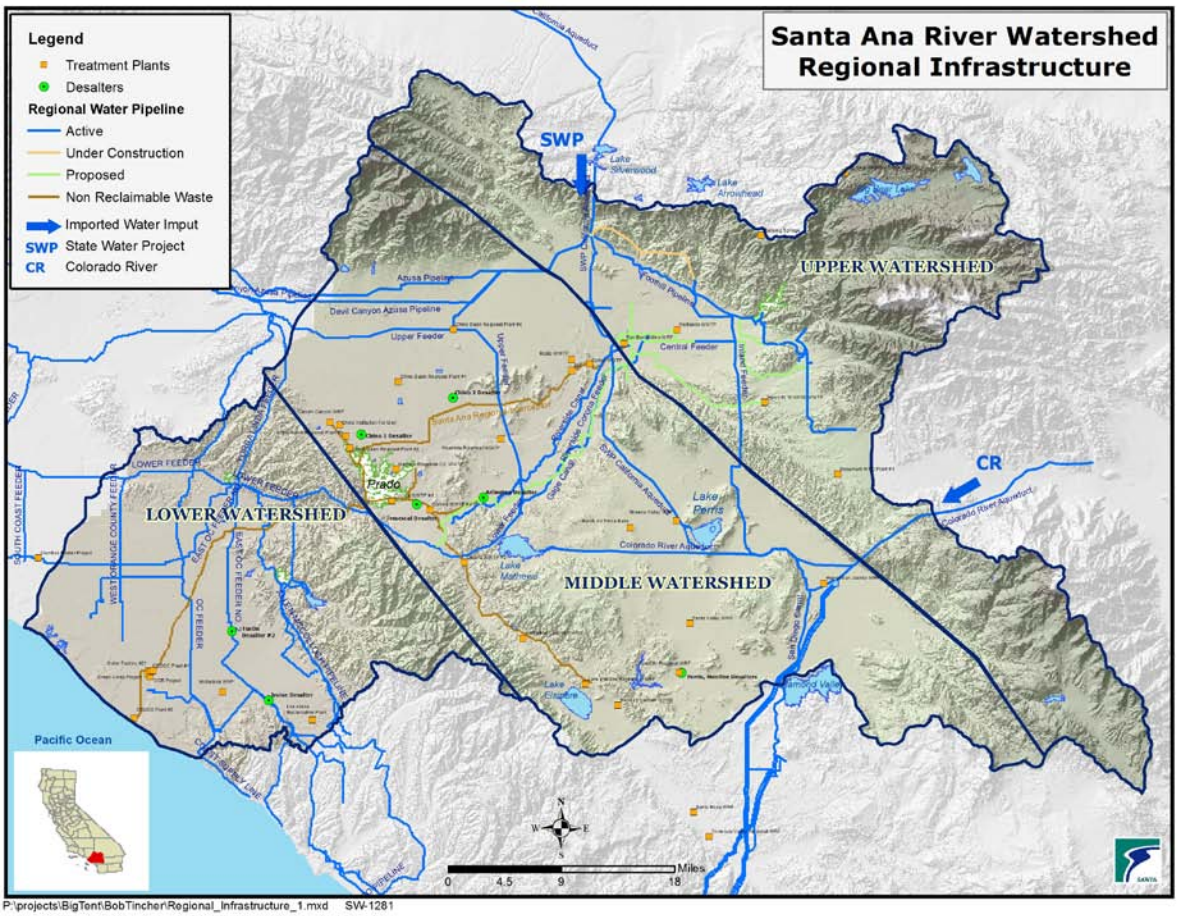
In 2005, the amount of precipitation that flowed from rivers and streams that was diverted and used accounted for approximately 5% of the total water supply. Local surface water is largely seasonal, meaning that most of the water comes in the "wet" or rainy season, and is dramatically reduced in the "dry" season to snowmelt, natural springs, and treated wastewater flows. Facilities, such as dams and flood control detention basins divert and slow storm runoff providing additional opportunity for groundwater replenishment. In the upper watershed, only a portion of storm runoff is being diverted and used as surface water. In other portions of the watershed, the exact opposite is true. Much of the

runoff from the upper and middle watershed is captured by the U.S. Army Corps of Engineers' Prado Dam and later is used by the Lower Watershed. A similar opportunity is available in the upper watershed at the U.S. Army Corps of Engineers Seven Oaks Dam and other dams in the watershed.

Imported Water

The watershed relies upon imported water for about 1/3 of its water supply. Water is imported into the area by MWDSC (SWP and CR), SGPWA (SWP) and Valley District (SWP). Current and predicted reliability of the SWP was taken from DWR's *The State Water Project Delivery Reliability Report 2009* (August 2010). **Figure 5.4-4** shows the regional infrastructure and the entry points for the SWP and the CR.

Figure 5.4-4 Regional Infrastructure within the Watershed



As shown on **Figure 5.4-4**, there are significant regional pipelines (48 inch diameter and larger) and surface storage reservoirs in the watershed. These pipelines provide opportunities for water transfers, especially in an emergency situation. **Table 5.4-1** provides a list of surface water reservoirs in the watershed and their capacities.

Table 5.4-1 Surface Water Reservoir Capacities

Reservoir	Capacity (acre-feet)
Lake Arrowhead	48,000
Big Bear Lake	73,000
Diamond Valley Reservoir	800,000
Lake Elsinore	45,000
Canyon Lake	12,000
Lake Mathews	178,500
Lake Perris	120,000
Prado Dam	Flood control and conservation
Seven Oaks Dam	Flood control (conservation pending)
Lake Silverwood	74,970
Irvine Lake	25,000

Recycled Water

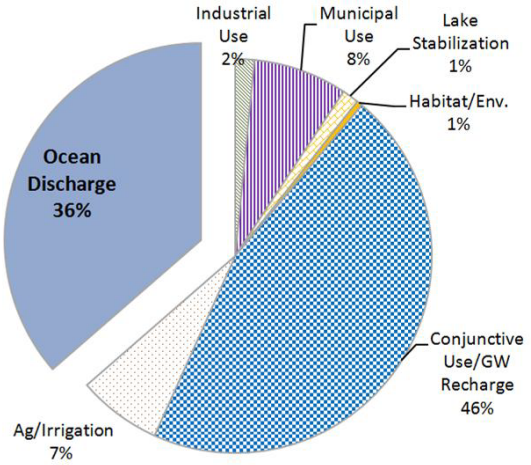
Water recycling, also known as water reclamation or water reuse, is a reliable, economically feasible, and environmentally sensitive means to preserve the State's potable water resources, assist with drought mitigation, and reduce the demand on potable water supplies.

Statewide, over 669,000 (AF) of wastewater is recycled each year according to the State Water Resources Control Board (SWRCB). Currently, recycled water is used to irrigate agricultural crops, urban landscapes, golf courses, and freeway medians; replenish groundwater basins; flush toilets and urinals; and act as a barrier to sea water intrusion into freshwater groundwater basins. It is also increasingly used by industry in cooling processes, in new home and other construction, and for other purposes. In the future, the level of recycling will increase to help meet the needs of the State's burgeoning population.

Current Conditions in the Watershed

Recycled water has been used in the watershed for many years to supplement local and imported potable supplies. Water reclamation involves treating wastewater to State standards so that the water is safe for State-approved applications. Currently, over 285,000 AFY of recycled water is being used to meet groundwater recharge (72%), municipal (12%), agricultural irrigation (11%), lake stabilization (2%) , industrial (2%), and habitat and environmental (1%) water needs within the Santa Ana River Watershed (see **Figure 5.4-5**). The 285,000 AFY includes approximately 100,000 AFY of tertiary treated wastewater that flows down the Santa Ana River from San Bernardino and Riverside Counties that is recharged by OCWD in surface recharge basins in Anaheim and Orange. OCWD generally captures all of the river flows, except during periods of high storm flow. As seen in in **Figure 5.4-5** only 36% of recycled water in the watershed, or 157,000 AF is currenlty being discharged to the ocean.

Figure 5.4-5 Current Rate of Recycled Water Use within the Watershed

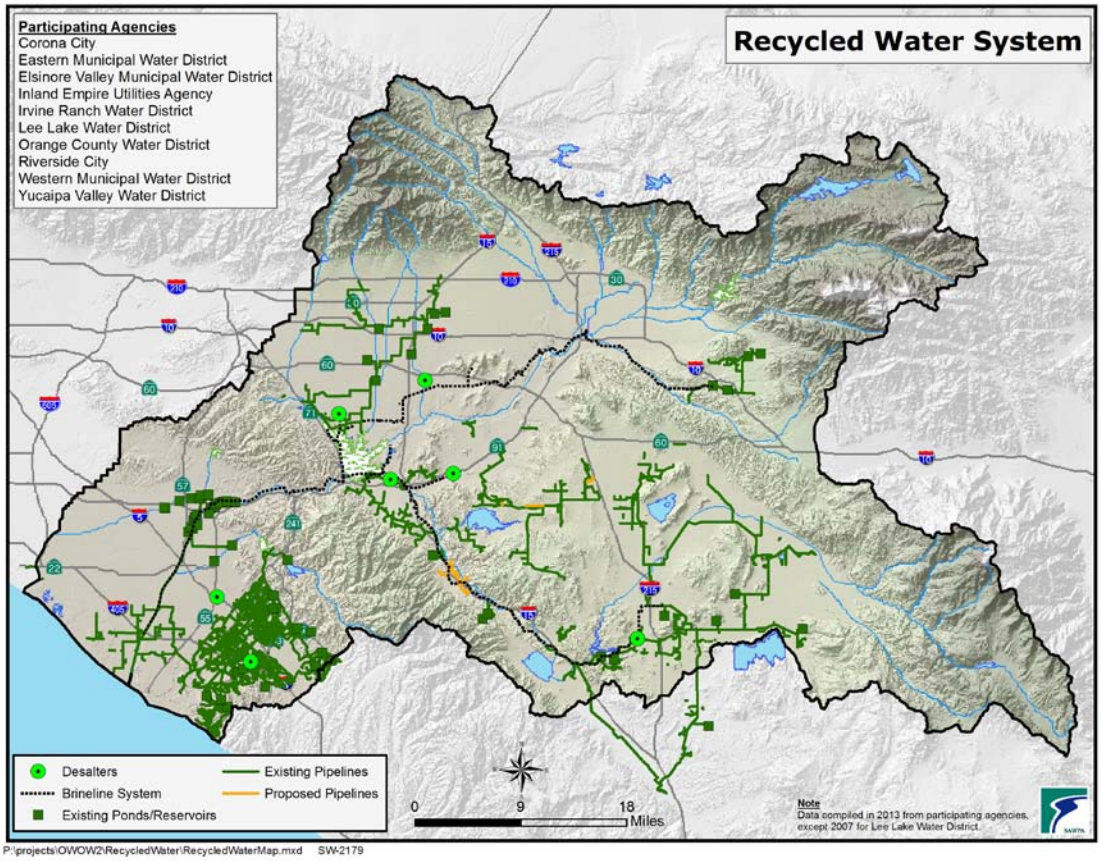


The 100,000 AFY is considerably more than the 42,000 AF at Prado Dam required by the 1969 Orange County Judgment. As demands continue to increase and other supplies become less reliable, the upper and middle watershed have plans to increase recycling. Over time, any reduction in treated wastewater flow in the river would have to be replaced by OCWD recycling more of the wastewater that flows into the ocean, importing more water, desalting the ocean, or some other new source of supply. Tables 5a.8 through 5a.11 of **Appendix C** show the proposed increase in recycled water use in the upper watershed from 2015 through 2035.

Overall recycled water currently represents the third largest water supply source to the watershed, accounting for approximately 20% of total water demands. **Appendix C** includes information about existing and proposed treatment facilities, plant flow and recycled water use.

Figure 5.4-6 shows the recycled water systems in the watershed. Included in the display are existing and proposed recycled water pipelines, existing and proposed wastewater treatment plants, existing and proposed storage tanks, existing storage ponds, and the Inland Empire Brine Line. Agencies that provided map information include Big Bear Area Regional Wastewater Agency, City of Corona, City of Riverside, EMWD, EVMWD, IEUA, Irvine Ranch Water District, Lee Lake Water District (LLWD), Orange County Sanitation District (OCSD), OCWD, WMWD, and Yucaipa Valley Water District (YVWD).

Figure 5.4-6 Recycled Water Systems

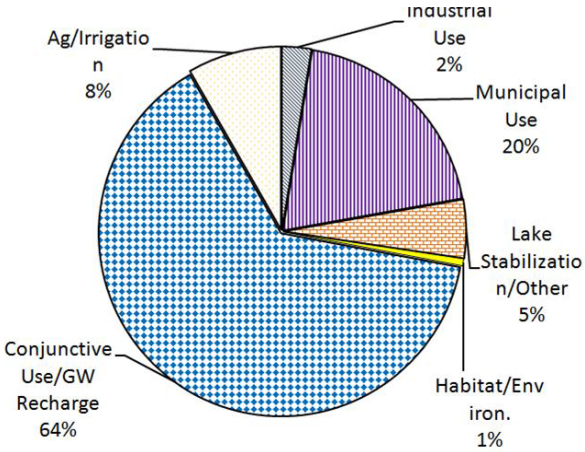


Proposed Recycled Use

As urban and suburban growth and development in the watershed continue, an increasing amount of recycled water will be available while the traditional demand by agricultural customers will decrease. This creates a challenge to establish a growing recycled water market for groundwater recharge, commercial, industrial, and institutional customers as well as developing innovative and creative markets elsewhere.

Current projections for 2035 indicate 432,000 AFY of water treatment plant flows will be recycled in the watershed, and 205,000 AFY discharged into the ocean. **Figure 5.4-7** depicts the estimated distribution of the recycled water in 2035.

Figure 5.4-6 Projected 2035 Rate of Recycle Water Use within the Watershed



Current Management Strategies

Current management strategies include the planned and conceptual recycled water projects as described below.

EMWD has completed a Recycled Water Strategic Plan to identify the preferred strategy to be pursued in developing its recycled water system through the year 2030. The principal goal of the Strategic Plan was to develop a preferred long term strategy for highest beneficial reuse of recycled water. EMWD's Recycled Water Strategic Plan recommended the Indirect Potable Reuse (IPR) Project, using advanced treated water for recharge of basins in the Hemet/San Jacinto Water Management Plan area. Currently, EMWD is working on a phase I planning study. This next step in the planning process consists of determining blending water strategy, brine disposal alternatives, salt balance considerations, regulatory requirements, facilities needs assessment & constraints analysis and program cost analysis. This phase will produce 5,000 AFY, and is scheduled to be completed in 2020.

City of Riverside - The SWRCB approved the City of Riverside's wastewater change petition on May 20, 2008. The primary condition of the Order requires that the City of Riverside discharge not less than 25,000 AFY of treated wastewater from its Regional Water Quality Control Plant to the Santa Ana River. The Order also modified the purpose of recycle water use to include municipal, industrial, and agricultural purposes and expanded the place of use to included areas within the City's limits, the City's water service area boundary, and within the boundary of the Jurupa Area Plan to reflect diversion of treated wastewater to recycled water use sites. To be able to meet these future projected needs without increasing the City of Riverside's reliance upon imported State Water purchases, it will be critical for the City of Riverside to significantly expand its use of the recycled water recently made available.

In addition to the description of the City of Riverside's recycled water efforts, the City of Riverside Public Utilities also received a master reclamation permit from the Regional Water Quality Control Board.

IEUA recently developed a Three Year Business Plan to rapidly expand the recycled water distribution system and increase recycled water use by 35,000 AFY. The capital program emphasizes increased system storage as well as distribution system piping and piping to reach high capacity recharge sites. The business strategy, while regional in nature, is founded on the principle of partnerships with IEUA member agencies, both from a water marketing standpoint and a capital facilities standpoint. The partnerships are having the effect of "supercharging" the capital program through conversion of member agency owned local potable water facilities to regional recycled water facilities.

LLWD has completed a recycled water master plan that will allow for the connection of the local parks and schools in the near future. They also have partnered with the City of Corona in its Ground Water Management Plan for the basins underlying LLWD's boundaries. LLWD currently is investigating potential groundwater recharge options.

OCWD and OCSD jointly developed the GWRS. In 2011, the GWRS produced 72,000 AF of recycled water. OCWD is constructing the Initial Expansion of the GWRS. This project will increase the amount of water produced by 31,000 AFY. When construction is completed in 2014, the total amount of water produced by the GWRS will be 103,000 AFY. OCWD is also evaluating an additional expansion of the

GWRS. Implementation of additional expansion of the GWRS would further reduce the amount of effluent discharged into the ocean. Because they reduce the amount of water discharged into the ocean, expansions of the GWRS are a new regional water source that would increase the net overall supply of water to the watershed.

City of Riverside in May 2013, the Regional Water Quality Control Board adopted Order No. R8-2013-0028 granting the City of Riverside Public Utilities a waste discharge requirements and master reclamation permit for distributing recycled water.

Valley District does not own or operate a wastewater treatment plant within its service area. However, recycled water is part of the region's water budget as they move toward the future. The City of San Bernardino Municipal Water Department is planning a "clean water factory" that may produce up to 14,000 AFY in the future.

WMWD expanded its recycled water portfolio with the expansion of the Western Water Recycling Facility (WWRF) in 2011. The plant is capable of producing up to three Million Gallons per Day (MGD) of tertiary-treated recycled water. Plans call for eventually expanding to five MGD.

WMWD possesses an extensive non-potable distribution system that includes both storage and pumping capabilities. This system functions as the backbone distribution system to expand use of recycled water (for irrigation) within its service area. One major commercial area (Meridian Business Center) and one large residential community already are dual-piped for recycled water use and a new Riverside Unified School District (RUSD) high school has been retrofitted to allow recycled water use. Two new large residential projects (including a golf course development) will be conditioned to install dual plumbing. WMWD also will work with RUSD to dual plumb new campuses, including a new middle school west of the Orangecrest area.

The City of Riverside is still working with WMWD to conduct joint planning for recycled water use. At this time, the City does not plan to deliver recycled water to Riverside's greenbelt. The system also will distribute non-potable groundwater through the legacy canal system thereby maximizing use of local water resources.

WMWD is working with the Riverside County Ben Clark Training Center to site a large recycled water storage impoundment on their facility located just south of Van Buren Boulevard and west of I-215. This proposed 600 AF impoundment would serve the County as a dive/water training facility while providing wet weather storage for recycled water produced by the WWRF, a truly unique and innovative use of recycled water.

Finally, WMWD is in the early stages of evaluating the use of recycled water to recharge local groundwater basins as a new source of supply. As total summer irrigation demands likely will exceed recycled water supply, recharge will probably be limited to winter months. Close coordination with the Regional Board and California Department of Public Health (CDPH) will be required.

YVWD adopted a Strategic Plan in August 2008, which outlines the methods used to maximize the use of recycled water to meet future water demands. This policy requires new homes to install dual water meters to provide potable water and non-potable water to each property. The use of recycled water

delivered to residential and commercial properties for irrigation is expected to reduce future potable water demands by 50%-60% per equivalent dwelling unit. This policy will require YVWD to implement a salinity control program which will provide extremely high quality recycled water to new neighborhoods providing a sustainable water supply for the future.

Other reclamation projects in the watershed include innovative uses such as toilet and urinal flushing in high-rise buildings and schools as well as residential landscaping irrigation, as evidenced by recycled water programs in IRWD.

Barriers and Constraints

Challenges related to recycling projects include: regulatory requirements, brine line constraints, storage/seasonal constraints, financial constraints, water quality management, and public perception. They are discussed below.

Regulatory Requirements

An important component of maximizing local supplies is the ability to safely and efficiently regulate and permit recycled water use. California's laws governing the permitting of recycled water were established more than 20 years ago, and are in need of updating to communicate that recycled water is a valued commodity, not a waste. Additionally, the current permitting framework establishes multiple recycled water permitting paths and overlapping jurisdictions overseeing the process which has resulted in confusing, costly delays and often inconsistent requirements.

To address some of these concerns, the Recycled Water Act of 2013 is currently making its way through the legislative process with the support of many water agencies and water reuse proponents. This bill will address barrier to recycled water use. It will align recycled water spill reporting and incidental runoff in codes, and authorize SWRCB permitting of advanced treated water. Clear, comprehensive legislation is required to maximize the use of recycled water in the future and to further reduce reliance on imported water.

In November 2011, the CDPH released draft regulations regarding recycling water for public comment. These draft regulations pertain to groundwater replenishment with recycled water. CDPH reviewed the public comments and released another draft in March of 2013. The final proposed version will proceed through the formal regulation adoption process and will be subject to public review and comment as part of that process.

Storage/Seasonal Constraints

The recycled water supply is not dependent on weather patterns; supply is fairly constant throughout the year. For these reasons, recycled water is viewed as one of the most reliable sources of water in the Watershed. However, because recycled water is used primarily for irrigation purposes and associated seasonal demands, recycled water demands can be variable and are often affected by weather and the season. In some areas, demands increase in dry years. However, wet years generally pose a greater operational challenge as customer demand decreases and storage facilities fill. Storage during periods of low demand is necessary to meet high demand during other times of the year. The amount of available recycled water storage varies greatly between agencies. Some have little or no storage and others have

thousands of AF of storage. Each agency's existing and proposed recycled water storage facility capacities, excluding groundwater basins, are shown in **Appendix C**.

Financial Constraints

The cost of infrastructure to produce, store, and distribute recycled water is expensive. Given that demands for recycled water are more scattered throughout communities, recycled water distribution pipelines are built only where demands justify the expense and where customers agree to use recycled water. This is especially true where sites need to be retrofitted to use recycled water as opposed to newly constructed sites where rules may dictate its use. Other issues include the cost of recycled water use to the customers as well as administration of the recycled water system by both the distributor and user. Because of the cost, there are sites where there may be willing customers but no infrastructure to serve them. Grant funds and other forms of financial aid can help make some projects viable, but other projects still may not be financially viable.

Other issues include the cost of recycled water use to the customers as well as administration of the recycled water system by both the distributor and user. Many agencies are unable to charge the true cost to produce this high quality water due to the stigma attached.

Costs associated with recycled water use could include retrofitting of existing systems, required inspections and cross-connection shutdown testing, employee training, and use site maintenance. Administrative requirements include extensive permitting, recordkeeping, and reporting requirements.

Each use area also must have a Site Supervisor knowledgeable of the use area system and recycled water use restrictions. The Site Supervisor must be available at all times to correct any condition that does not conform to use area requirements specified by regulations and the recycled water distributor.

Water Quality Management

Higher TDS source water, such as the Colorado River (up to 650 mg/l average) adds cost because TDS removal, or demineralization, requires energy intensive reverse osmosis. Residential use of water typically adds 200 to 300 mg/L of TDS to the wastewater stream, and self-regenerating water softeners can add another 60 to 100 mg/L. If an area receives CR water with a TDS of 650 mg/L, and residents add 300 mg/L through normal use, the recycling facility will produce water with a TDS concentration of 950 mg/L. This would not meet basin plan objectives anywhere in the watershed. It is also problematic for industrial customers and virtually unusable for many agricultural customers which limit the marketability. Nutrients such as nitrate present similar issues as TDS.

Public Perception

Public perception of recycled water is changing! One successful example of this is OCWD's GWRS project that undergoes an advanced treatment process including two membrane filtration systems – microfiltration and reverse osmosis, and treatment by ultraviolet light and hydrogen peroxide. Once purified, the water is sent to recharge basins where it seeps into the ground, like rain, and blends with groundwater. The GWRS provides a new drought-proof water source for northern and central Orange County, reducing reliance on imported water. Additionally, the GWRS will save additional funds in the future by improving the quality of the water in the Orange County groundwater basin. This successful

effort utilized widespread public outreach activities involving the scientific, political, and other communities to assist in informing the public and addressing potential public perception issues.

Evaluate Water Supply Reliability

Water supply reliability for the Watershed was evaluated using the scenarios given in the Urban Water Management Planning Act (**Table 5.4-2**) and using some additional scenarios developed by the Water Resource Optimization Pillar (**Table 5.4-3**).

Table 5.4-2 Water Supply Reliability Scenarios Provided in the Act

Scenario	Description
Average conditions*	What are the water supply reliability vulnerabilities given average supplies to the region?
Single year drought*[1]	What are the water supply reliability vulnerabilities given a single year of drought?
Multi-year drought*[1]	What are the water supply reliability vulnerabilities given a multi-year drought?
50% reduction in imported water supplies*[1]	What are the water supply reliability vulnerabilities if the Watershed loses 50% of imported water supplies?
Natural Disaster	What are the water supply reliability vulnerabilities if a catastrophic interruption occurs due to an earthquake or other disaster?

Table 5.4-3 Additional Water Supply Reliability Scenarios Evaluated as part of the OWOW Process

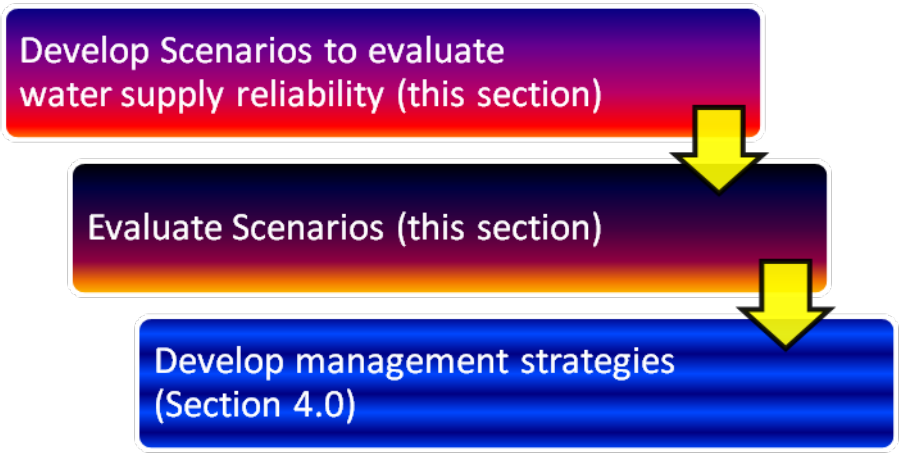
Scenario	Description
Climate Change	What are the water supply reliability vulnerabilities given the assumed effects of climate change as presented in the Draft 2007 State Water
Zebra and/or Quagga Mussels	What are the water supply reliability vulnerabilities of the Zebra Mussel and/or the Quagga Mussel were to infiltrate the SWP?
Sediment Transport	How does sediment transport at Seven Oaks Dam and/or Prado Dam affect water supply reliability?
Wildfire	How does the threat of wildfire affect water supply reliability?
Channel Armoring	How does channel armoring in the Santa Ana River affect water supply reliability?
Water quality degradation	How does water quality degradation affect water supply reliability?
Terrorism	How does terrorism affect water supply reliability?

*Scenario presented in the Catastrophic Interruption, Urban Water Management Planning Act.

Collectively, **Tables 5.4-2** and **5.4-3** provide a complete list of the evaluated scenarios.

All of the scenarios pose a threat to water supply reliability. The evaluation consisted of analyzing anticipated water supplies for each of these scenarios to determine if they are adequate to meet the anticipated demands. If anticipated demands are less than anticipated supplies, the system is deemed reliable. If anticipated demands are greater than anticipated supplies, water management strategies will need to be developed to offset these deficits. **Figure 5.4-8** provides an overview of the evaluation process.

Figure 5.4-7. Overview of the Water Supply Reliability Evaluation Process



The scenarios analyzed in this document represent a "snapshot" in time. As new challenges and constraints to water supply reliability are identified, they will require evaluation.

Evaluation of Water Supply Reliability Scenarios

Every urban water supplier that either provides over 3,000 acre-feet of water annually or serves more than 3,000 or more connections is required to assess the reliability of its water sources over a 20-year planning horizon considering normal, dry, multiple dry years and other scenarios. The scenarios evaluated in OWOW are summarized in **Table 5.4-4**. The assessment of water sources is reported in an UWMP, which is to be prepared every 5 years and submitted to DWR. DWR reviews the UWMPs to ensure they have completed the requirements from the Urban Water Management Planning Act (Division 6 Part 2.6 of the Water Code §10610 - 10656). Current and predicted reliability of the State Water Project used in the UWMPs was taken from the Department of Water Resources *The State Water Project Delivery Reliability Report 2009* (August 2010).

In November 2009,SB X7-7 (Steinberg) was passed requiring urban water suppliers to reduce per capita use 10% by 2015 and 20% by 2020. This required reduction in per capita consumption is reflected in the 2010 UWMPs which were used to evaluate water supply reliability for the watershed. This legislation results in a significant reduction in demand since OWOW 1.0 which eliminated the deficit between supplies and demands shown in OWOW 1.0. In each of the UWMP scenarios, the watershed is able to meet its projected demands plus the 10% Reliability Margin with the projected supplies. However, it is

important to recognize that both the reduced demand and anticipated supplies are dependent upon a significant public investment. In the Proposition 84 process, the total estimated cost for projects that reduce demand and improve supply is over $4 billion and that does not include ongoing operations and maintenance costs.

To eliminate the potential for "double-counting", OWOW supplies are characterized by their source. For example, imported water recharged into a groundwater basin would be labeled "imported water" rather than "groundwater".

Table 5.4-4 Summary of Water Supply Reliability Scenarios

Short-term Impacts	Long-term Impacts
Catastrophic Interruption	Average Hydrologic Conditions
Earthquake[1]	
Power outage[1]	Single-year Drought Hydrologic Conditions
Mussels[1]	
Wildfire[1]	Multi-year Drought Hydrologic Conditions
Water quality degradation	
Terrorism[1]	Climate Change[1]
	Sediment Transport[1]

1 Actual effects uncertain.

Reliability Margin

There are many hydrologic uncertainties including future weather patterns, the effects of climate change and possible legal restrictions that could be placed on water supplies such as past restrictions placed on the SWP. To help prepare for these and any other uncertainties, it is recommended that supplies exceed demands thereby providing a buffer, or "reliability margin". For the OWOW process, this reliability margin was established at 10% to be consistent with other water budgets in the watershed.

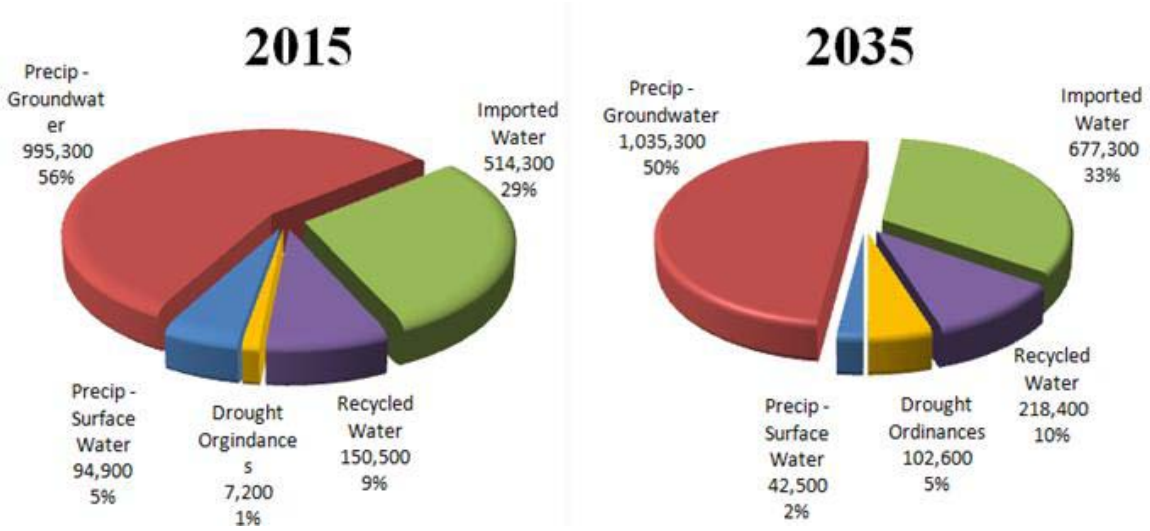
Average Year (Baseline)

Evaluating average water supplies provides a "baseline" for comparison purposes. **Figure 5.4-9** summarizes the data for 2010 and 2035, which is based upon the UWMPs but also includes the following proposed stormwater capture projects that were not included in the UWMPs:

Table 5.4-5 Stormwater Capture Projects Not Included in UWMPs but Included in OWOW Water Budget

Project	Amount (AF/Y)		
	IEUA	SBVMWD	WMWD/RPU
Chino Basin Recharge Master Plan	5,000		
Stormwater capture along the tributaries of the Santa Ana River (Active Recharge Project)		20,000	8,000
Riverside North [Basin] Aquifer Storage and Recovery Project	5,000	5,000	5,000
Total	10,000	25,000	13,000

Figure 5.4-8 Summary of Water Supply Estimated from UWMP Data for 2015 and 2035



Local precipitation presently meets about 60% of the demand and, due to increasing demand over time, is projected to meet about 50% of the demand in 2035. Other sources of supply and/or conservation measures are needed to meet the remaining 40% and 50% of demands, respectively. Although "drought ordinances" result in a reduction in demand, they have been presented as a supply to add emphasis and ensure they are not overlooked.

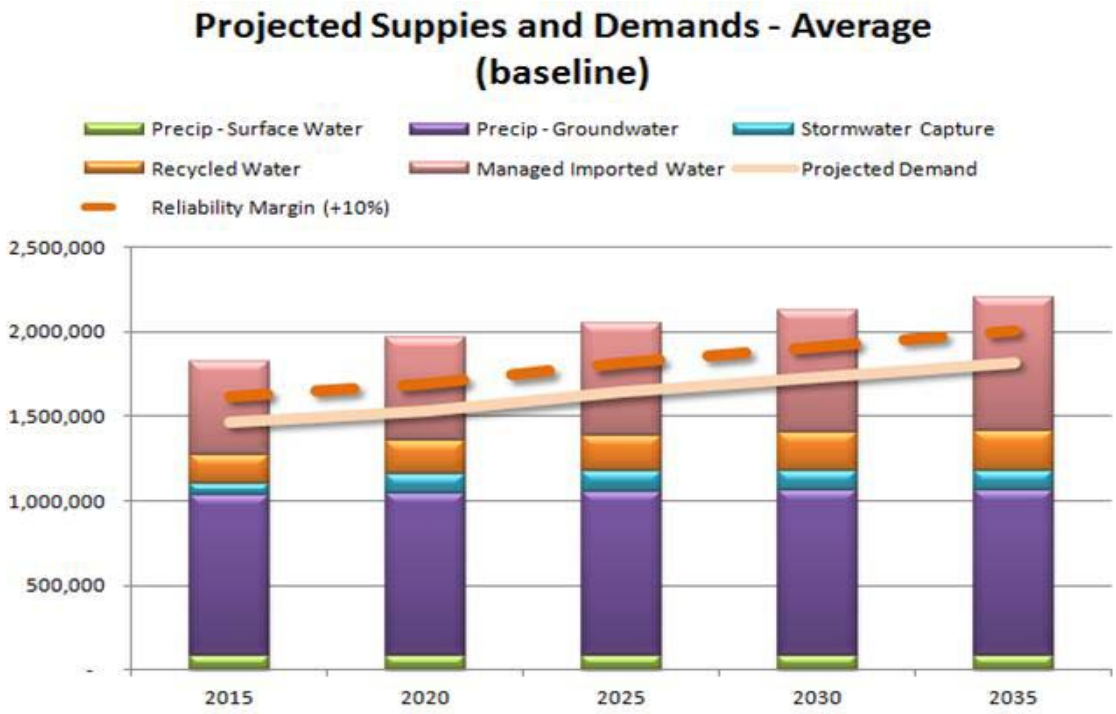
Given average hydrologic conditions, **Figure 5.4-10** shows that the watershed will be able to meet its needs through 2035 with a reliability margin of 15% in 2035. However, although the watershed, as a whole, will be able to meet demands, the SGPWA is projecting a 16,500 AF deficit. So, the watershed will need to work together to help overcome this deficit. The overall projections based on the UWMP data are positive and are generally based on the following assumptions:

1. Future local precipitation patterns will be the same as past precipitation patterns (possible effects of climate change addressed later in the chapter)

2. The predicted reliability of the State Water Project as taken from the Department of Water Resources *The State Water Project Delivery Reliability Report 2009* (August 2010) is accurate
3. Imported water projections include possible effects of climate change
4. Imported water will be managed to store wet year supply for use during dry years
5. Future demands will match the estimated demand
6. The watershed will invest over $4 billion in water conservation and infrastructure projects
7. Significant investments will be made to improve the reliability of imported water supplies as detailed in MWDSC's 2010 Regional UWMP

Given these unknowns, the watershed should continue to strive toward efficiency and toward projects that provide redundancy in case hydrologic projections are incorrect.

Figure 5.4-9 Comparison of Total Supply (by source) versus the Projected Demand

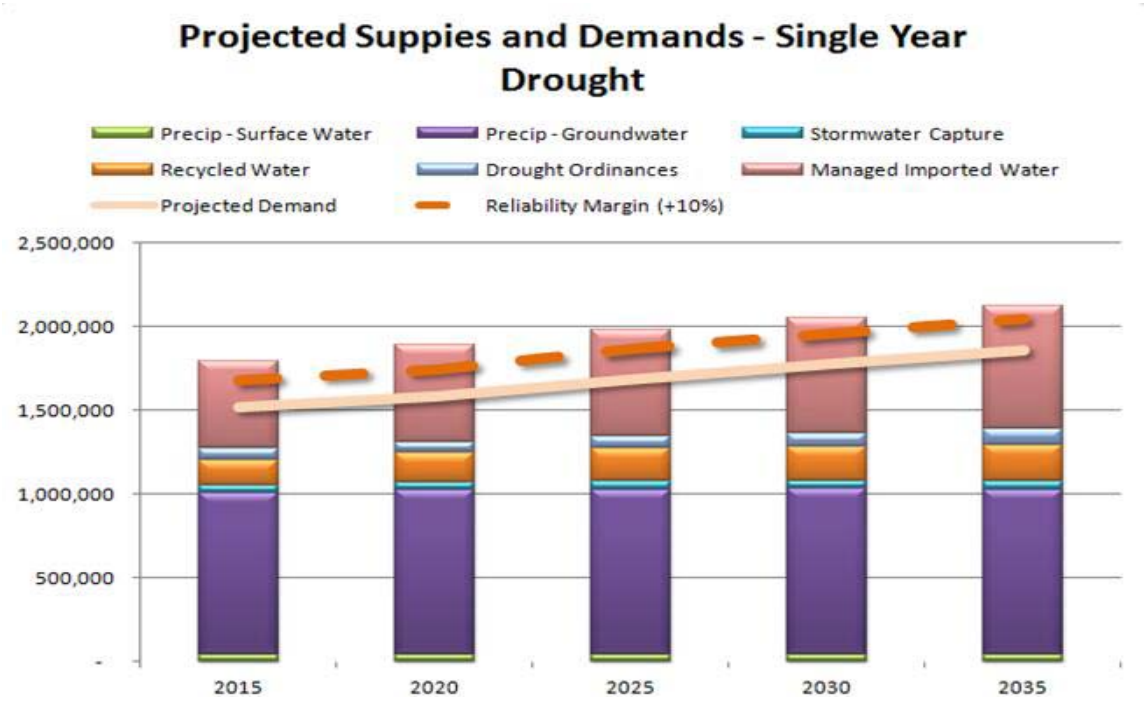


Single-Year Drought

Figure 5.4-11 summarizes the UWMP data for a single year drought. Nearly all of the water agencies defined the single-year drought as the year that they historically received the lowest amount of imported water. The watershed will be able to meet its demands in a single year drought with a reliability margin of 11% in 2035. The watershed is able to make it through a single year drought by relying on the various imported water storage programs that store water when it is available during wet periods for use during drought periods and on recycled water which is not impacted by weather. Although the watershed, as a whole, has enough supply to meet demand during a single year drought, the SGPWA projects a shortage of 27,000 AF in a single year of drought. Much of this deficit would be met by taking groundwater out of storage in the SGPWA service area. The overall projections based on the UWMP data are positive and are generally based on the same seven assumptions listed above.

Given these unknowns, the watershed should continue to strive toward efficiency and toward projects that provide redundancy in case hydrologic projections are incorrect.

Figure 5.4-10 Anticipated Supply (by source) versus Projected Demand for a Single Year of Drought



Multi-Year Drought

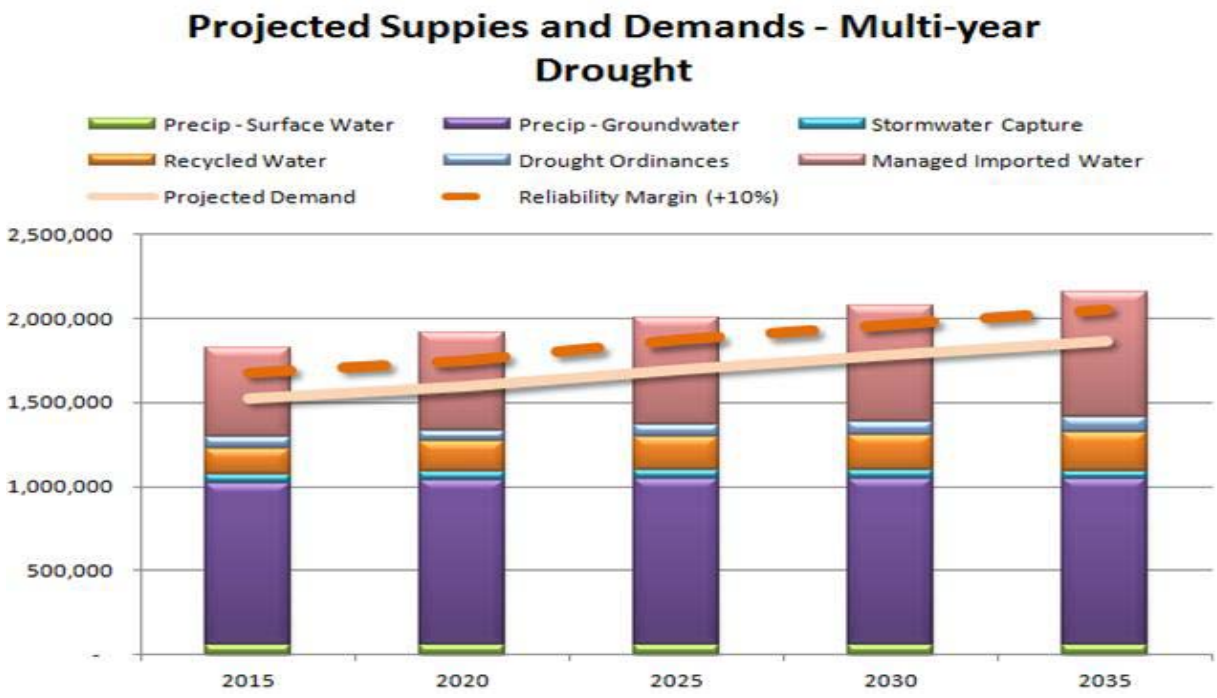
This scenario evaluates the water supply reliability for the Watershed assuming a multi-year (3 year) drought. Nearly all of the water agencies chose a3 year period that had the lowest, historic delivery of imported water.

Figure 5.4-12 summarizes the UWMP data for a multi-year drought and shows that the watershed will be able to meet demands with a reliability margin of 13% in 2035, higher than a single year drought. Although a 3 year drought lasts longer, the average entitlement available during multi-year drought is slightly higher than the entitlement available during a single year drought. The watershed is able to meet its needs during a multi-year drought due mostly to the storage programs implemented by MWDSC, Valley District, SGPWA, and others. However, despite the overall ability to meet demand, SGPWA is expecting a deficit of about 23,000 AF during a multi-year drought. Much of this would be met by withdrawing groundwater from storage in the SGPWA service area.[3]The overall projections based on the UWMP data are positive and are generally based on the seven assumptions listed above.

[3]Upper Santa Ana River Watershed Integrated Regional Water Management Plan, Table 3-12, November 2007, pg. 3-20.

Given these unknowns, the watershed should continue to strive toward efficiency and toward projects that provide redundancy in case hydrologic projections are incorrect.

Figure 5.4-11 Projected Supply (by source) versus Projected Demand during a Multi-Year Drought



Evaluate a Short-term 50% Reduction in Imported Water Supplies

One of the scenarios water agencies must evaluate as part of their UWMP is a 50% reduction in supplies. To maintain consistency with this requirement, it was decided to evaluate a 50% reduction in imported water supplies for the watershed. However, both a single year drought and multi-year drought result in greater reductions in imported water supplies than 50%. Since both the single-year drought and multi-year drought scenarios reduce imported water supplies more than 50%, this scenario is less conservative and, therefore, did not warrant detailed evaluation.

Evaluate a Catastrophic Interruption in Water Supplies

The water system that serves both local and imported water to the watershed is made up of a variety of facilities including pipes, canals, and levees that are all susceptible to damage or failure from a catastrophic event. The catastrophic events that were evaluated as part of the OWOW process are earthquake, Delta levee failure, power failure, wildfire, and terrorism. While catastrophic events may not be avoided entirely, measures can be developed and set in place to minimize the interruption to water service following a catastrophic event. These measures include: assessing the vulnerability of systems, quantifying available resources, determining optimal use of resources, increasing the flexibility of distribution systems, increasing regional coordination and establishing repair priorities.

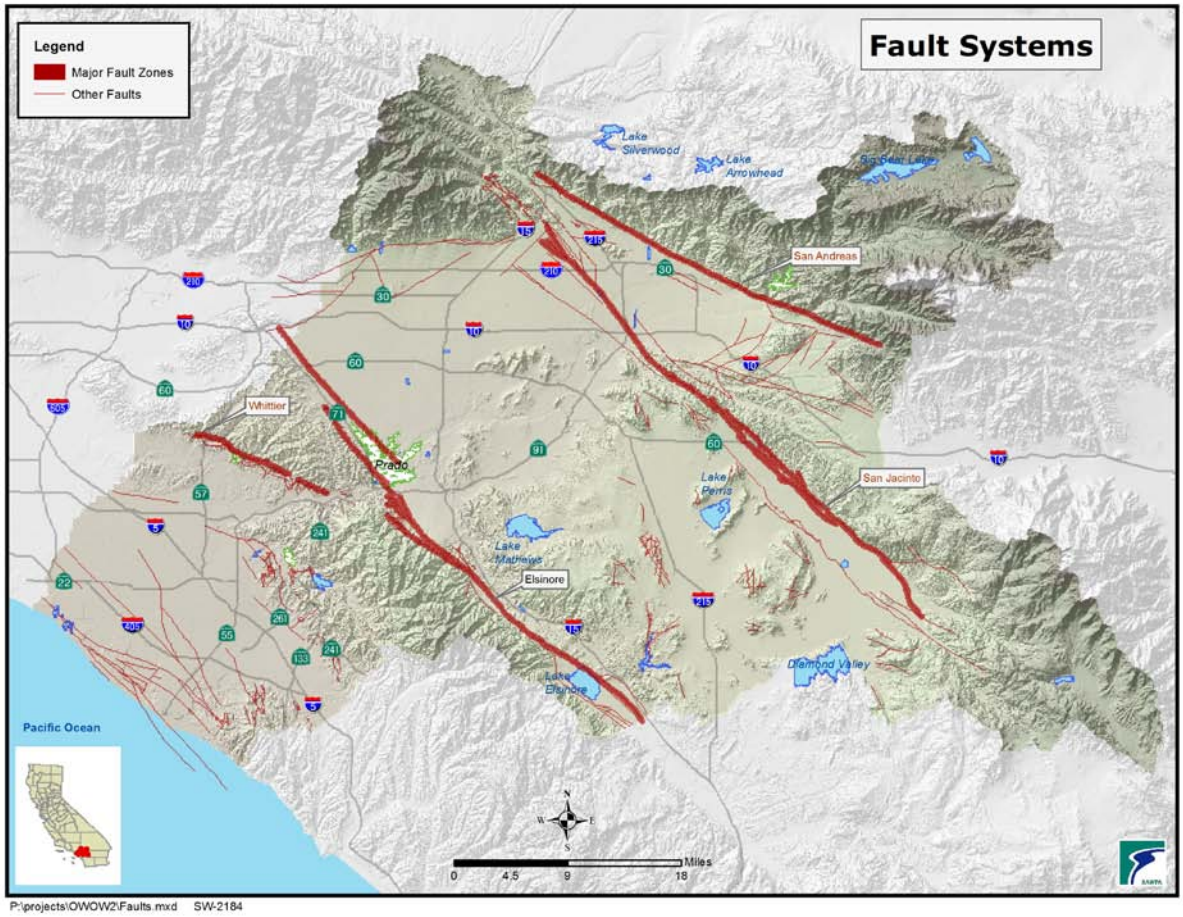
Evaluate the Effect of an Earthquake on Water Supplies

The watershed is located within a seismically active region of Southern California. As shown on **Figure 5.4-13**, six active major earthquake faults and a number of smaller faults extend through the Watershed. As shown on **Table 5.4-6**, a seismic event along one of the major active faults within the Watershed could result in an earthquake in the range of magnitude 6.0 to 8.0 on the Richter Scale.

Table 5.4-6 Estimated Maximum Richter Magnitude for Various Faults in the Watershed

Fault	Maximum Magnitude
San Andreas	8.0
San Jacinto	7.5
Elsinore	6.8
Chino	6.5
Whittier	6.8
Peralta Hills	6.6
Puente Hills	7.5
Newport/Inglewood	6.9

Figure 5.4-12 Major Earthquake Faults in the Watershed



Depending on the intensity of the earthquake and location of the epicenter, catastrophic damage and interruptions of water service could occur throughout the watershed. Regional water conveyance systems, including the CRA; the Upper, Lower and Coastal Feeder Systems; as well as the East Branch of the California Aqueduct (also known as Foothill Pipeline) could sustain significant damage from a major earthquake that would interrupt the delivery of imported water supplies to the watershed. It also would make it difficult to transport water regionally within the watershed. Additionally, damage could occur to local water transmission systems operated by retail water agencies within the watershed, such as the Gage Transmission Main, Waterman Transmission Main, and the Riverside Canal. In addition to the potential damage to transmission facilities, damage also could occur to groundwater pumping facilities, water storage facilities, and water treatment plants as a result of seismic shaking impacts and/or from liquefaction impacts in areas that have high groundwater tables.

Based upon past seismic events, it is assumed that the impacts of a seismic event will be short-term. Due to the uncertainty tied to seismic events (magnitude, epicenter, etc.), it is not possible to determine the exact impact of a seismic event on water supply. However, the watershed can implement strategies that will better prepare the watershed for such an event. These strategies are provided in the *Management Strategies to Improve Water Supply Reliability* section.

Evaluate a Delta Levee Failure on Water Supplies

The Sacramento-San Joaquin Delta is a region where two of California's largest rivers, the Sacramento River and the San Joaquin River meet. It is the hub of the State's water supply system. About two-thirds of all California residents and millions of acres of irrigated farmland rely on the Delta for water from the SWP and the Federal Central Valley Project. The structural integrity of the delta levee system is vital to maintain water supplies to southern California. However, the Delta levee system is aging and a considerable amount of the land along the Delta levee system has subsided below sea level. The earthen levees are subject to risk from earthquakes, flooding and salt water intrusion. Catastrophic damage sustained by the levees would result in interruptions to SWP supplies to the Watershed due mostly to saltwater intrusion. The New Orleans levee failures resulting from Hurricane Katrina on August 29, 2005 particularly prompted awareness of the severe consequences and export outages that would occur with catastrophic multi-island levee failures resulting from a severe earthquake in the Sacramento-San Joaquin Delta region.

A severe earthquake in the Delta region of a frequency similar to a Hurricane Katrina would result in multiple levee breaches and slumping causing multi-island failures. There would be extensive levee slumping and overtopping resulting from liquefaction of levee foundations, severely hampering levee restoration efforts. This failure scenario would allow excessive salinity to enter the central and south Delta increasing salinity at the export pumps significantly beyond levels for municipal and agricultural uses. The difficulty in restoring water quality at the pumps is driven by the inability to displace saline water out of that region.

For example, a June 2005 report by Jack Benjamin and Associates in association with Resource Management Associates and Economic Insights (Preliminary Seismic Risk Analysis Associated with Levee Failures in the Sacramento – San Joaquin Delta June 2005) indicates a 6.5 earthquake in the western Delta would generate a 21-island failure and a 28-month duration water supply disruption in the Delta to restore levees in their current state. There is a 66% probability that a 6.5 magnitude earthquake will occur in the Delta region by 2032 or within the next 20 years (United States Geological Survey Delta Seismic Risk Report 2005). Further, one or more dry years immediately before or within the disruption period would substantially increase economic impacts and may lengthen the disruption period due to less availability of fresh waters within the Delta.

Determining the length of time water supplies will be shut down by severe earthquakes is influenced by a combination of complicated hydrodynamic, emergency response, water operations, and water treatment and geotechnical factors. In 2005, DWR released a study that estimated Delta levee failure resulting from a 6.5 magnitude earthquake would eliminate deliveries on the SWP for 28 months[4]. Assuming a 28 month repair period, the effects of this catastrophic interruption would be very similar to a multi-year drought. Thus, the strategies that are implemented to offset the effects of a multi-year

[4] Jack R. Benjamin & Associates, Inc. in association withResource Management Associates and Economic Insights, Preliminary Seismic Risk Analysis Associated with Levee Failures in the Sacramento – San Joaquin Delta, June 2005, Page 18.

drought also would be helpful to offset this event. Should the levee failure(s) occur after a drought period when stored water supplies are severely depleted, other emergency strategies would need to be implemented, such as extreme conservation and mandatory rationing.

In 2011, an independent analysis of impacts to levees along the Middle River emergency freshwater pathway have been performed by URS under contract to MWDSC considering all seismic hazards relevant to the central Delta pathway region (Estimated Levee Displacement Pathway Alignment, Sacramento - San Joaquin Delta, California July 2011). The analyses indicates that levee slumping in excess of ten feet can occur from an earthquake with a frequency of a hurricane Katrina resulting from liquefaction of loose sand levee foundations, placing the levees below high tide elevation and severely hampering restoration efforts. More recent RMA analyses supporting the preparation of the 2012 DWR Delta Flood Emergency Preparedness, Response and Recovery plan studies suggest that, depending on hydrologic conditions, several years would be required for a catastrophic multi-island levee failure to restore salinity concentrations necessary for municipal water quality needs at the export pumps. RMA analyses contained in the February 2007 Moffat & Nichol report (Delta Emergency Preparedness, A Feasibility Plan for Protecting the State's Water Supplies during a Catastrophic Collapse of Multiple Delta Islands) indicate that reservoir releases alone could not restore water quality at the export pumps adequate for municipal use.

The MWDSC Board has sought a comprehensive emergency preparedness and response strategy to safeguard water exports from the Delta. On April 10, 2007 the Board approved a strategy to respond to a plausible multiple-island failure scenario by restoring an emergency freshwater pathway through the Delta generally along Middle River to water export facilities in the south Delta in approximately 6-months. This strategy has been accepted by DWR in their preparation of a Delta Flood Emergency Preparedness and Response Plan (EPRRP) due for publishing in 2012 in coordination with the U.S. Army Corps of Engineers. This Plan covers a wide range of emergency response strategies ranging from isolated levee failures, up to and including catastrophic multiple-island failures causing severe water export disruptions. MWDSC has also promoted levee improvements on pathway levees to reduce levee slumping and breaches, as well as advance placement of redundant materials stockpiles such as rock and sheet pile for the reliable closure of breaches to ensure freshwater pathway restoration. Both pathway levee improvements and preparedness stockpiles have been initiated and will continue to completion in the next several years.

Evaluate a Power Failure on Water Supplies

Power failure can occur as isolated incidents or as part of larger event such as a regional power grid failure caused by a catastrophic event. During a large-scale power failure, water conveyance systems, water treatments plants, and ground water pumping wells could cease to operate.

Most power officials believe that under a scenario when only a portion of the regional power grid fails, the loss of power should not extend beyond 24 hours. However, under a scenario where all three grids of the North American Grid fail, the loss of power could extend for days. Depending on how much of the grid is lost and the length of time it takes to repair, the loss of power could have a profound impact on water delivery.

Power failure likely would have a short-term impact on water supply reliability. Due to the uncertainty of this scenario, it is not possible to determine the exact impact. However, the same strategies that will help to prepare for an earthquake will help prepare for such an event. These strategies are provided in the *Management Strategies to Improve Water Supply Reliability* section.

Evaluate Wildfire on Water Supplies

Wildfire can damage water delivery facilities or the power infrastructure used by water facilities. In addition, the loss of vegetation resulting from a wildfire can change runoff patterns, increase sediment, and reduce water storage. There also are potential water quality concerns associated with ash falling into surface reservoirs, which could overwhelm filtration plants as turbidities increase by orders of magnitude.

The effects of wildfire likely will have a short-term impact on water supply. Possible effects are loss of vegetation, change in runoff patterns, increased sedimentation, reduced natural water storage, and ash falling into surface reservoirs. Due to the uncertainty of this scenario, it is not possible to determine the exact impacts. However, the same strategies that will help to prepare for an earthquake will help prepare for such an event. These strategies are provided in the *Management Strategies to Improve Water Supply Reliability* section.

Evaluate the Effects of Terrorism on Water Supplies

There is always a possibility that water infrastructure could be targeted by terrorists. Water agencies have responded to this potential threat by reducing public access to water infrastructure or even the information about infrastructure. They have also responded by increasing security measures at their facilities.

The effects of a terrorist attack likely will cause short-term reduction in water supply reliability. Due to the uncertainty of this scenario, it is not possible to determine the exact impacts. However, the same strategies that will help to prepare for an earthquake will help prepare for such an event. These strategies are provided in Management *Strategies to Improve Water Supply Reliability.*

Evaluate Delta Flow Restrictions on Water Supplies

On December 14, 2007, U.S. District Judge Oliver Wanger issued an Interim Remedial Order to protect the threatened Delta smelt, which restricted water exports from the Delta to agricultural and urban customers of the SWP and CVP. In December 2008, the U.S. Fish and Wildlife Service issued a biological opinion covering Project effects on Delta smelt. In June 2009, the National Marine Fisheries Service issued a biological opinion covering Project effects on winter-run and spring-run Chinook salmon, steelhead, green sturgeon, and killer whales. The biological opinions replaced opinions issued earlier by the federal agencies.

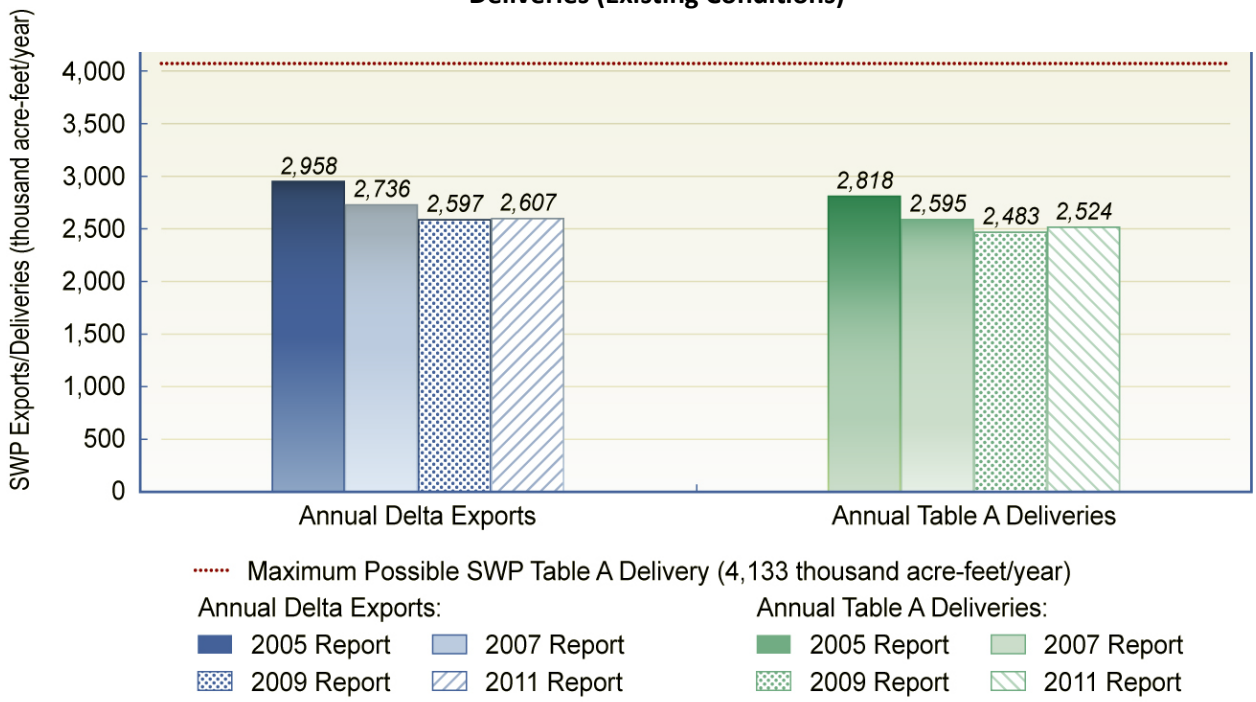
The 2008 and 2009 biological opinions were issued shortly before and shortly after the Governor proclaimed a statewide water shortage state of emergency in February 2009, amid the threat of a third

consecutive dry year. Both opinions have been subject to considerable litigation. Recent Court decisions and settlements have changed specific operational rules in 2011-12, and both opinions have been remanded to the agencies for further review and analysis.

The impacts of the above decisions were analyzed by DWR in The State Water Project Delivery Reliability Report 2009 which was used in the 2010 UWMPs.

DWR has also released a draft update titled "The State Water Project DRAFT Delivery Reliability Report 2011". As shown in the **Figure 5.4-14**, estimated average annual Delta exports and SWP Table A water deliveries have generally decreased since 2005 but are slightly up as compared with 2009. Under existing conditions, average annual Delta exports have decreased since 2005 from 2,960 thousand acre-feet per year (taf/year) to 2,610 taf/year in 2011, a decrease of 350 taf or 12%. Similarly, average annual Table A deliveries have decreased since 2005 from 2,820 taf/year to 2,520 taf/year in 2011, a decrease of 300 taf or 10%.

Figure 5.4-13 Trends in Estimated Average Annual Delta Exports and SWP Table A Water Deliveries (Existing Conditions)



A number of water agencies, federal and state resources agencies and non-governmental organizations are currently engaged in the development of a Bay Delta Conservation Plan (BDCP). An explanation of the BDCP is provided later in this chapter.

Evaluate Climate Change on Water Supplies

Temperature data suggest that California's climate is getting warmer. This phenomenon is being referred to as "climate change". Climate change could have an impact on water supply reliability. In a recent report, the U.S. Bureau of Reclamation provides potential impacts including reduction in snow pack, changes in the timing and amount of runoff, changes in the frequency and magnitude of extreme storm events, increased watershed vegetation demands due to higher evapotranspiration rates, changes in future agriculture and urban water demands, changes in sea level rise, and increased potential for salt water intrusion to the Sacramento-San Joaquin Delta and groundwater basins near the coast.

From a water management perspective, the strategies that increase reliability without climate change will also increase reliability with climate change. As a result, there are no specific strategies targeting climate change. To plan for this and other unknowns, the Watershed has implemented a "reliability margin" of 10%. More discussion about climate change impacts are included in the Energy and Environmental Impact Response pillar chapter later in this OWOW 2.0 report.

Evaluate the Impact of Quagga and/or Zebra Mussels on Water Supplies

Quagga mussels (*Dreissenabugensis*) were discovered in Lake Mead in January 2007 and rapidly spread throughout the lower Colorado River and Metropolitan's CRA system. Quagga mussels are indigenous to the Ukraine and are a related species to the better-known zebra mussels (*Dreissenapolymorpha*). Similar to the zebra mussel, which was most likely introduced to the Great Lakes in the late 1980s via ship ballast water, Quagga mussels were introduced to Lake Mead most probably through the translocation of boats. Although the introduction of these two species into drinking water supplies does not typically result in violation of drinking water standards, invasive mussel infestations can adversely impact aquatic environments. Two areas of relevance for aquatic environments used as sources of drinking water are the potential for clogging of intakes and raw water conveyance systems via attachment of high numbers of mussels to surfaces and a long-term potential for rendering lakes more susceptible to deleterious algae blooms. Control of mussel infestations can cost water conveyance systems millions of dollars annually in facility improvements and/or maintenance. Quagga mussels have infested water conveyance systems linked to the lower Colorado River. There is concern that Quagga mussels could become more widespread and infest the State Water Project System and other watersheds by boats and watercraft vehicles. Preventive measures implemented include boat inspections prior to entering un-infested water bodies and decontamination (clean, drain and dry) of vessels departed infested water bodies.

Evaluate the Effects of Santa Ana River Channel Armoring and Sediment Transport

The Santa Ana River is a productive recharge "facility" that helps replenish the Watershed's groundwater basins. The transport and deposition of sediment along the Santa Ana River is critical to maintaining existing groundwater recharge capacity. A sandy river bottom allows surface water to percolate easily into the groundwater basin and maximizes recharge rates. If this process is interrupted, the amount of recharge can be reduced.

The transport and disposition of sand within the Santa Ana River is interrupted when it is trapped by both the Seven Oaks Dam and Prado Dam. Seven Oaks Dam traps sediment at the base of the San Bernardino Mountains while Prado Dam traps sediment just upstream of Orange County. This entrapment of the sand causes negative impacts on the recharge capacity of the riverbed.

In addition, as the sand washes away and no longer is being replaced by sand from upstream, the river bottom gradually transitions from a "soft" bottom to a coarser bottom that includes heavier material such as gravel and cobbles. The gravel and cobbles eventually interlock with fine sediments and form an "armored" layer. This process is referred to as "channel armoring," which can reduce the recharge rate of the river. A Groundwater Recharge Study prepared by OCWD estimates that the armoring of the Santa Ana River has resulted in a loss of percolation of about 1% per year. With a long-term degradation of recharge rates, longer stretches of the river would be needed to recharge the same amount of water that is recharged today or some other kind of mitigation would be required.

Additionally, sediment loading behind the two dams can reduce surface water storage volumes. The continued build up of sediment behind the dams will reduce the overall storage capacity of the dams, which will, in turn, reduce the amount of storm flow that can be temporarily stored and released for groundwater recharge.

Channel armoring could reduce recharge rates along the Santa Ana River. Sediment transport could reduce storage volumes behind Prado Dam and Seven Oaks Dam thereby reducing the amount of stormwater that can be captured and used.

Evaluate the Effects of Water Quality Degradation on Water Supplies

Water supply reliability in the Watershed can be improved by reinstating local water resources that have been avoided due to poor water quality. For example, some groundwater basins in the Watershed have been impacted by high concentrations of salts. In the past, rather than pump and treat this poorer quality water, many groundwater producers chose to replace it with another source(s) of water that did not require treatment. This same approach also has been used in groundwater basins that were polluted by volatile, organic compounds and other contaminants. If, instead, these local resources were to be treated and used, they effectively would become "new" sources of water within the watershed which would act to increase water supply reliability. Water supply reliability can be increased if water resources that were avoided in the past due to poorer water quality are, instead, treated and utilized.

Summary of Evaluation Results

The water supply reliability scenarios that were evaluated as part of this analysis can be divided into two general categories, short-term impacts and long-term impacts. **Table 5.4-4** summarizes the two general categories. Those in the short-term category are difficult to quantify. Those in the long-term category are more easily quantified with the exception of climate change, sediment transport and channel armoring which are still under investigation. However, all of the recommended water management strategies to help the watershed overcome the long-term impacts will also help the watershed endure the short-term impacts.

Based on the data from 2010 UWMPs, the watershed is able to meet its demands in the average, single-year drought and multi-year drought scenarios while maintaining a reliability margin of 10%, or greater, to help offset future unknowns. These results assume that:

8. Planned infrastructure will be constructed
9. Demand projections are correct
10. It will rain locally the same in the future as it did in the past
11. The watershed will continue to manage imported supplies by storing water in wet years for later use during droughts

Given the uncertainty in these assumptions, it is recommended that the watershed continue to invest in planned infrastructure projects and that it implement a broad range of management strategies to diversify supplies thereby enhancing water supply reliability.

Water Management Strategies and Watershed-wide Project/Program Concepts to Improve Water Supply Reliability

To increase reliability, the following water management strategies are recommended:

Reduce Demand
Stormwater Capture
Optimize Imported Water
Recycle Water
Increase storage
Implement emergency measures

Each of these strategies enhances reliability to offset unknowns.

Water agencies throughout the watershed are implementing one, or more, of these strategies for their individual service areas. The goal of OWOW 2.0 was to develop watershed-wide project/program concepts, based on these strategies, which would increase water supply reliability throughout the watershed while reducing costs. The following sections discuss a number of watershed-wide project/program concepts organized by water management strategy. Some of the concepts build on OWOW 1.0 and some are new for OWOW 2.0. The concepts marked with a ☑ are recommended for focus over the next five years.

Reduce Demand

One of the ways the watershed can increase water supply reliability is to reduce demand, wherever possible, by using water more efficiently. The following concepts are recommended for the watershed:

☑*Water Rate structures that encourage conservation*

Estimated benefit: Help achieve a 20% demand reduction by 2020.

Water rates that increase as consumption increases have been shown to reduce consumption. While many of the retail water agencies have this type of rate structure in place, there are still agencies in the watershed that do not have this type of rate structure.

☑*Public education to encourage water conservation*

Estimated benefit: Help achieve a 20% demand reduction by 2020.

Educating the public on the State and watershed's water supply system is a crucial component to implementing permanent change in water use habits. If the public understands the water supply situation, they will understand the need to raise rates, change water use habits permanently and continue investing in the Watershed's water supplies.

Outdoor conservation

Estimated benefit: Help achieve a 20% demand reduction by 2020.

The upper and middle watershed uses 60 – 70% of its water outdoors. A significant number of outdoor water use efficiency programs are already in place. The watershed has made considerable progress in this area through the Inland Empire Garden Friendly, and other, programs. More details about this and other suggested water conservations measures are discussed in the Water Use Efficiency Pillar chapter later in the OWOW 2.0 Plan.

Reduce evapotranspiration

Estimated benefit: More investigation required

One of the only measurable "losses" in the Watershed is evapotranspiration. Evapotranspiration is the combined water loss associated with evaporation and transpiration. Evaporation is the movement of water to the air from the land surface and water bodies. Transpiration is the movement of water into plants and the subsequent loss of water as vapor through its leaves. The losses associated with evaporation might be reduced by developing and implementing specific programs to increase the amount of shaded area such as planting trees or constructing shade structures. However, more analysis is required to estimate savings and determine whether the increased water use by any new shade trees would offset any potential decrease in evaporation associated with their shade. This strategy would be most appropriate in the areas of the watershed with the highest evaporation rates, namely the upper and middle Watershed.

Optimize Imported Water

The Watershed is dependent upon imported water to meet approximately one-third of its needs into the future. However, the reliability of this source of water has proven to be less certain, at times, due to unforeseen circumstances such as the "Delta Smelt Decision" in 2007. This historic decision resulted in one of the single largest court-ordered SWP delivery reductions in state history to protect the endangered Sacramento/San Joaquin Delta smelt (fish). As a result of this and other problems in the

Delta, the SWP operates below its delivery capacity. However, the Watershed may be able to implement strategies that could help offset the various uncertainties, and possibly even increase the amount of imported water available to the watershed.

☑*Wet Year Imported Water Storage Program*

Estimated benefit: Improved reliability and reduced cost by storing water locally.

This concept was introduced in OWOW 1.0 as "Base Load Off of Imported Water" and involves storing imported water (primarily SWP water) in wet years for later use in dry years. This not only improves water supply reliability but could also reduce costs by dramatically reducing the amount of imported water that is purchased during dry years when the "market rate" is the highest. The watershed has made strong progress on this strategy. The largest State Water Contractor for the watershed, MWDSC, has had a wet year storage program for many years that stores water in surface reservoirs and groundwater basins including the Central Valley during wet years for later use in dry years. San Bernardino Valley Municipal Water District, the State Water Contractor serving the upper watershed, has stored over 100,000 acre-feet of imported water in the San Bernardino Basin Area since 2008.

The Pillar explored the possibility of improving this concept by changing the MWDSC storage location from the Central Valley to the watershed. The most likely and effective way to change the storage location would be for the MWDSC member agencies (4 of the 5 SAWPA agencies) in the watershed to purchase more imported water during wet years when they typically purchase less, if any, imported water due to its higher cost. The Pillar worked on a possible MWDSC payment structure that would lower member agencies costs during wet years but result in full compensation to MWDSC in the dry year when the water is used. MWDSC currently offers a similar groundwater storage program titled "Conjunctive Use Program (CUP)".

The proposed payment structure was compared to the existing CUP program. The evaluation assumed a 120,000 AF storage program (imported water and storage capacity of approximately 60,000 AFY and 40,000 AFY of groundwater pumping capacity) and was based on a 10 year cycle consisting of 2 wet years, 3 dry years and 5 normal years. **Table 5.4-7** below compares the MWDSC CUP program to the proposed Program (key differences are bolded).

Table 5.4-7 Term Comparison between MWD's CUP Program and Proposed Program

Component	MWD CUP	Proposed Program
"Put" Capacity	60,000 AFY	60,000 AFY
"Take" Capacity	40,000 AFY	40,000 AFY
Program Storage Capacity	120,000 AF	120,000 AF
Storage/Extraction Capital Cost	None	Paid by member agency

Annual Administration Costs	None	None
Program Term	25 years	25 years
Storage Losses	Varies by basin	Varies by basin
Total Payment at Time of "Put"	None	• MWDSC Variable Supply Cost • MWDSC Variable Treatment Cost • Watershed Incentive
Total Payment at Time of "Take"	• MWDSC Tier 1 (at time of extraction)	• MWDSC Tier 1 (at delivery) less "Put" Payment

A preliminary economic analysis suggested that the revenue from the proposed program was comparable to the existing MWD CUP program. However, the proposed program would result in water being stored in the watershed which could increase participation and thereby increase the amount of water in storage within the watershed.

☑*Bay Delta Conservation Plan*

Estimated benefit: Would restore the reliability of the SWP to 78% from 60% which equates to about 131,400 acre-feet per year for the watershed.

The proposed BDCP offers a solution that would restore reliability to the SWP. Nearly all of the reduction of imported water deliveries through the SWP is due to environmental and other problems in the Delta. The proposed solution which will achieve the "coequal goals" of improving the health of the ecological system as a whole while also protecting SWP deliveries (SWP deliveries are less than 20% of the total flow through the Delta) is to transport SWP deliveries "around" or "under" the Delta in some sort of "Delta conveyance facility." Not only would this "Delta conveyance facility" increase the reliability of deliveries, but it would also improve SWP water quality in the form of lower Total Dissolved Solids (TDS). The decrease in TDS will reduce water recycling costs. The BDCP which is being prepared by a group of local water agencies, environmental and conservation organizations, state and federal agencies, and other interest groups includes such a facility. When complete, the BDCP will provide the basis for the issuance of endangered species permits for the operation of the state and federal water projects. Implementation of the plan will occur over a 50 year time frame.

Imported Water Banking

Estimated benefit: Dry year supply.

Although the watershed has significant groundwater storage, it is not easily accessible to the entire watershed. In some cases, it may be more efficient to participate in a groundwater storage opportunity

outside the watershed. These storage opportunities are often referred to as "water banks" and are located throughout the State.

The wholesale water agency that covers 80% of the watershed, MWDSC, already has significant water banking throughout the state. Since OWOW 1.0, the upper watershed has participated in a water bank in the central valley and in Big Bear Lake to help keep surface water treatment plants operational during drought periods. The watershed has made significant progress in this area.

Prevent Invasive Species from Clogging Infrastructure

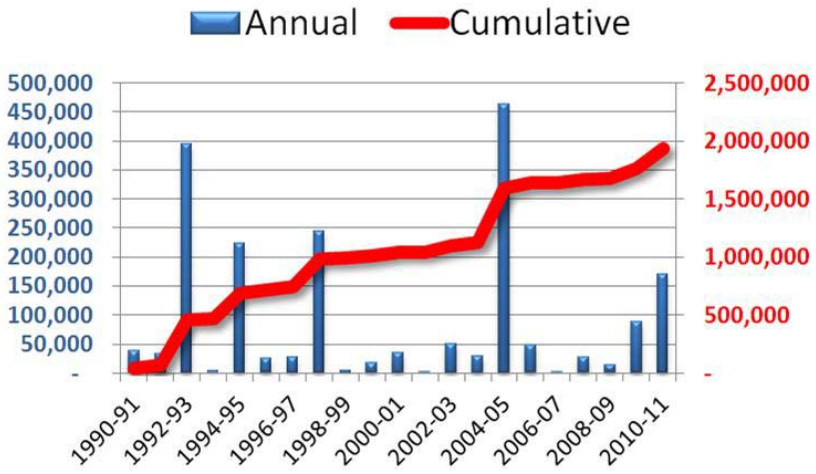
Estimated benefit: Consistent deliveries.

Quagga Mussels and the closely related Zebra Mussels are small shellfish, usually less than half inch in size. Once only found in the Great Lakes, the Quagga Mussel has now been discovered in Lake Mead, the CRA, and a local reservoir in San Diego County. They will live and reproduce in pipes causing them to clog. Once they are established, they are very difficult to eradicate. Quagga Mussels can be controlled by super chlorination and drying out, sometimes requiring the temporary drawing down of water supplies. The additional maintenance costs associated with controlling these mussels could cost tens of millions of dollars a year. There is concern that Quagga Mussels could become more widespread and migrate into the watershed through untreated water pipelines or larvae carried on boats and other watercraft. The watershed should participate in any programs, such as the one initiated by MWDSC, which target the prevention of these species from entering water infrastructure.

Stormwater Capture

Capturing stormwater runoff within the Watershed is challenging due to the "flashy" hydrology. The watershed tends to be either extremely wet or extremely dry. **Figure 5.4-15** shows how much stormwater has gone to the Pacific Ocean since 1990. As the figure shows, most of the un-captured flow came during "flood" years when it was nearly impossible to capture. However, even if these flood years are removed, there is still an opportunity to capture more stormwater throughout the watershed.

Figure 5.4-15 Stormwater Flow Lost to the Ocean since 1990



Because stormwater originates in the mountains, it can be diverted at high elevation enabling it to be delivered by gravity thereby saving energy costs. Diverting it higher in the watershed also provides the opportunity to use the water more than once before it reaches the ocean. In addition to the low energy cost, this water is also high quality, which helps the Watershed achieve both surface water and groundwater quality objectives established by State and Federal agencies. The watershed is currently working on the following projects that will use more local stormwater. More details on many of these projects, though briefly described below, are covered in greater detail **Chapter 5.8 Stormwater: Resource and Risk Management** later in the OWOW 2.0 Plan report.

☑*Enhanced Santa Ana River stormwater capture below Seven Oaks Dam*

Estimated benefit: 12,000 acre-feet per year.

The upper watershed has obtained a water right for the additional stormwater detained by Seven Oaks Dam and is presently designing facilities that will enable the diversion of up to 500 cfs and up to 80,000 acre-feet per year.

☑*Enhanced stormwater capture from the tributaries of the Santa Ana River*

Estimated benefit: 28,000 acre-feet per year.

The upper watershed has completed the conceptual design of improvements and operational changes that result in additional stormwater capture from the tributaries of the Santa Ana River.

☑*Riverside Basin Aquifer Storage and Recovery Project*

Estimated benefit: 28,000 acre-feet per year.

Riverside Public utilities, in partnership with Valley District and others are developing a design for a rubber dam that would cross the Santa Ana River and be used to divert flows into off-stream recharge basins.

☑*Enhanced Santa Ana River stormwater capture at Prado Dam*

Estimated benefit: 10,000 acre-feet per year.

The lower watershed is evaluating the feasibility of increasing the Prado flood season water storage elevation from 498 MSL to 505. After the Santa Ana River Mainstem flood control project is completed in approximately 2022, it may be possible to store water to higher elevations in Prado Dam for water conservation. A preliminary economic analysis of storing water to elevation 510 feet and 514 feet is summarized in **Table 5.4-8** below.

Table 5.4-8 Preliminary Economic Analysis - Enhanced Stormwater Capture at Prado Dam

Category	Storage to 510 feet	Storage to 514 feet
Estimated capital cost[1]	$54M	$125M
Estimated annual operations and maintenance cost	$300,000	$400,000
Estimated water yield (acre-feet per year)[2]	5,000	10,000
Estimated cost per acre-feet[3]	$600	$700

[1] Includes environmental mitigation

[2] Estimated water yield in comparison to year-round 505 ft storage

[3] Based on capital cost repayment over 30 years at 5% interest

☑*MS4 Credits*

Estimated benefit: Increased reliability by utilizing more local stormwater.

The Municipal Separate Storm Sewer Systems (MS4) permit process is intended, among other things, to increase the amount of stormwater captured and recharged in the watershed. These permits require the owner to construct their project in such a way to recharge stormwater on their site. However, in some cases, it may be more ideal from a water management perspective to recharge the stormwater somewhere upstream. One way to introduce flexibility into this process would be to allow owners to purchase "MS4 Credits" that could be applied to recharge projects in other locations. There may also be an opportunity to allow these credits to be used throughout the watershed. For example, a project in Orange County could purchase credits that could be used for a project in the upper watershed.

☑*Re-operate flood control facilities*

Estimated benefit: More investigation required.

Working with flood control agencies to re-operate flood control facilities with the goal of increasing stormwater capture increasing flood get away capacity and revising decades old storage curves. For example, when weather forecasts do not show any impending storms, the flood control agencies may be able to release stormwater at a slower rate. This relatively minor operational change would make stormwater flows easier to capture and put to use. It also would result in impounding the water longer, which would increase artificial recharge during the "holding period". This strategy has already been successfully implemented in some portions of the watershed.

☑*Size flood control facilities for stormwater capture*

Estimated benefit: Increased reliability by utilizing more local stormwater.

Another way to increase stormwater capture would be to work with flood control agencies to increase the size of existing, or new, detention basins. Larger detention basins would slow the flow and increase the recharge area, which would increase the amount of stormwater that is artificially recharged. In addition to this increased recharge, the larger basins also would provide greater flood protection. A related strategy would be to construct additional surface water reservoirs within the watershed. Unlike detention basins, which need to be drained every year before the flood season, surface water reservoirs provide the added flexibility of allowing the water to be stored until it is needed. In addition, surface water reservoirs also provide a storage location(s) for other sources of water such as imported water. Although effective, both of these strategies would be viable only in areas of the watershed that have vacant land.

☑*Forest First: Forest management for increased downstream stormwater capture*

Estimated benefit: Increased reliability by utilizing more local stormwater.

Another way to increase stormwater capture would be to work under the Forest First MOU with SAWPA to support collaborative projects among the U.S. Forest Service and downstream flood control and groundwater management agencies to support forest management including a) fuels reduction, b) chaparral restoration, c) meadows restoration, and 4) forest maintenance road runoff control. With collaboration between upstream and downstream parties, water flows from the forest may be spread more evenly over the hydrograph cycle allowing for slower and more even flows from the forest lands to the plains resulting in increased recharge. This will also result in less sediment transport particularly after forest burn events and water quality improvement downstream.

☑*Development Standards that enhance stormwater capture*

Estimated benefit: Increased reliability by utilizing more local stormwater.

Another strategy to increase stormwater capture would be to implement new development standards that promote the construction of infrastructure that increases the infiltration of stormwater such as porous concrete, infiltration galleries, and perforated pipelines. These facilities could be implemented in public areas such as parking lots, schoolyards, parks and greenbelts, as well as private areas, by establishing a requirement in local development codes.

Recycle Water

Treating and reusing wastewater, referred to as "recycled water", provides the most reliable sources of water in the watershed. Wherever recycled water can be put to use, it effectively replaces a like amount of potable water. Over the years, the watershed has seen significant accomplishments in the development of recycled water. In fact, at present, nearly all of the recycled water from the upper and middle watershed is being discharged into the Santa Ana River and is being reused at various locations downstream. In the future, the upper and middle watershed plan to develop enhanced recycling programs that could change the place of use for much of this resource. Should enhanced recycling occur in the upper and middle watershed, it would reduce the amount of recycled water flowing to the lower watershed. This could be offset in the lower watershed by increasing water recycling, increasing conservation measures, desalting the ocean and/or purchasing more imported water. There may also be an opportunity for the upper, middle and lower watersheds to leave their treated wastewater in the river in exchange for the lower watershed providing a "replacement" source, of like quantity and reliability, to the upper and middle watershed. This concept was first introduced in OWOW 1.0 and has been further developed in OWOW 2.0 as "Recycled Water Exchange".

☑*Recycled Water Exchange*

Estimated benefit: Although many details would need to be worked out, this type of concept could potentially save the watershed nearly $1/2 billion in capital costs and, perhaps even more, in energy costs not to mention the potential to reduce the amount of salt imported into the watershed.

This concept was first introduced in OWOW 1.0 and could save the watershed nearly $1 billion in facilities and, perhaps even more, in energy costs. The upper watershed currently delivers nearly all of its treated wastewater effluent to the lower watershed via the Santa Ana River. The Lower Watershed uses the effluent to recharge its groundwater basin and reduce the need for imported water.

This concept would exchange treated wastewater from the upper watershed for a like amount of imported water delivered to the upper watershed. The following summarizes this concept:

- *Treated wastewater flows remain in the river for lower watershed*– The Upper Watershed would continue to deliver treated wastewater to the Lower Watershed via the Santa Ana River instead of developing recycled water programs (the concept seems most feasible in areas without mature recycled water programs).
- *Lower watershed provides imported water Upper Watershed* – The Lower Watershed would essentially change the place of delivery for some of the imported water they are already planning to

import to the Upper Watershed which would replace the treated wastewater flowing from the Upper Watershed.

- *Comparable reliability* – Recycled water is 100% reliable and imported water is about 60% reliable. This concept would mitigate the reduced in reliability to the upper watershed by storing imported water in the upper watershed, or some other water bank, during wet years for later use in dry years.

A preliminary evaluation of this concept identified the following benefits as compared to current plans:

- *Less salt* – under this Program, the lower watershed would provide imported water to the upper watershed. The only source of imported water available to the upper watershed is SWP which is higher quality than Colorado River and many of the existing groundwater basins in the Watershed. To the extent that SWP water delivered to the upper watershed replaces CR water delivered to the lower watershed and/or is stored in a basin of lower water quality, there could be a water quality improvement in the watershed.
- *1/3 Return on investment*– under this program, the lower watershed essentially changes the place of delivery for imported water from the lower watershed to the upper watershed. Since approximately 1/3 of every acre-foot delivered to the upper watershed ends up as treated wastewater and back in the river, the lower watershed essentially receives 1 - 1/3 acre-feet for every acre-foot delivered, a 33% return on investment!
- *Lower cost – less energy* – The energy required to produce recycled water and to pump it up to higher elevation where it can be used throughout a water system is substantial. This concept would eliminate these energy costs. Since the imported water delivered to the upper watershed from the lower watershed would have been imported anyway, there is no increase in energy associated with this component of the concept.
- *Dry Year Reliability* – Recycled water is 100% reliable which benefits the lower watershed. Although imported water is only about 60% reliable, it can be stored in wet years so that it is available in dry years to improve the reliability. Thus, both the Upper and the lower watershed end up with a reliable supply.

☑*Recycled Water for Potable Use*

Estimated benefit: Improved reliability by increasing the amount of times water can be used

Legislation will be required to allow recycled water to be used for potable use. The watershed should work together to promote such legislation.

☑*Recycle sewage effluent from Orange County Sanitation District Plants No. 1 and No. 2 that is currently flowing to the ocean*

Estimated benefit: 157,000 acre-feet per year

As presented in the Recycled Water section of this chapter, OCSD expects to "dispose" of effluent into the ocean each year from its Plant No. 1. This effluent could be treated and used for a variety of

purposes including the offset of any reduction in recycled water flows to the lower watershed due to recycling in the upper and middle watersheds.

As presented in the Recycled Water section of this chapter, by 2030 the Orange County Sanitation District expects to "dispose" of effluent into the ocean each year from its Plant No. 2. However, based on current Department of Public Health (DPH) requirements, this water cannot be recycled because it includes the effluent from the Inland Empire Brine Line which contains discharges from the String fellow Hazardous Waste Site, and other sources that would require further characterization by DPH. The Watershed should consider working with DPH on a strategy that would allow this effluent to be recycled.

Importation of recycled water from outside the Watershed

There may be opportunities to import recycled water from outside the Watershed. Any recycled water imported into the watershed would be viewed as a new supply.

Recycled water use to offset potable demand

This is widely implemented by several agencies and part of the projected water supply portfolio

Desalt the Pacific Ocean

Estimated benefit: 54,000 acre-feet per year

The lower watershed borders the Pacific Ocean and while ocean desalination generally is considered technically and institutionally feasible, it is also expensive both in capital and operational costs and is subject to significant regulatory scrutiny depending upon the environmental impact of the specific project. It also requires significant base loaded energy that is costly. Over the last five years, a number of water agencies have been investing significant effort and funds in ocean desalination program development work. There are currently two sites along coastal Orange County that have completed extensive exploratory work and permit approvals to construct desalination facilities but to date neither completely permitted or successful in securing contracts for the supply.

The cost of this water is significantly more expensive than any other current source of supply. For this reason, the watershed should focus on the other strategies.

Increase Storage

In general, the hydrology for the watershed can be characterized by a short series of wet years followed by a longer series of dry years. When the wet years come, they tend to be really wet, or "flood" type years. Thus, a fundamental water management challenge for the watershed is to capture the water during wet years, when it is plentiful, and store it for later use during dry years. The water may be stored in surface water reservoirs or the groundwater basins within the watershed.

☑*Surface Water Storage*

Estimated benefit: Helps offset the effects of drought, climate change and emergencies

As shown in **Table 5.4-1**, the watershed is fortunate to have a number of surface water reservoirs. However, additional surface storage space would allow the capture of additional stormwater and "unused" imported water. Not only do surface water reservoirs provide a location to store water when it is available, but they also enhance reliability during a disaster. Therefore, the Watershed should work toward increasing surface water storage both inside and outside the region. Due to the fast development within the watershed, the number of potential reservoir sites inside the watershed continues to diminish every year. Potential surface storage opportunities outside of the watershed would include any additional reservoirs constructed as part of the SWP and/or the CRA.

☑*Groundwater Storage*

Estimated benefit: Helps offset the effects of drought and climate change

In addition to additional surface water storage, the watershed also should pursue the utilization of any unused groundwater storage in the watershed. Like a surface water reservoir, these underground reservoirs provide a place to store wet year supplies for later use during extended drought periods.

Some groundwater basins in the middle and lower watershed have been abandoned or have not been fully utilized due to high salt content, contamination, color, odor or some other concern. Projects to pump and treat water in these basins, or portions thereof, provide restoration of groundwater storage that may not have been historically available for municipal use. In addition to recovering the storage space, it could also result in new yield.

Emergency Measures Strategies

Estimated benefit: Improved recovery time following a disaster

Despite careful planning, there will still be catastrophic events and unforeseen circumstances. Although the timing and extent of such events or circumstances are unknown, the following strategies will help the watershed prepare for the unknown.

Local Emergency Plans

Each of the water agencies within the Watershed must have an emergency plan that complies with both the Standardized Emergency Management System (SEMS) and the National Incident Management System (NIMS).

Mutual Aid and Coordination

All of the water agencies should have mutual aid agreements in place. One mutual aid option used by many of the water agencies is to join the California Water/Wastewater Agency Response Network (Cal

WARN), www.calwarn.org. CalWARN provides a "standard" mutual aid agreement, and also maintains a database of personnel and equipment that could be made available during an emergency. It is recommended that each of the water agencies in the Watershed join CalWARN and "upload" their personnel and equipment data. In addition to participating in mutual aid agreements, the water agencies also may want to consider additional coordination with one another through a regional group. Two such groups already have been formed in the Watershed: Water Emergency Response Organization of Orange County (WEROC), and the Emergency Response Network of the Inland Empire (ERNIE). Water agencies should consider partnering with one of these groups or, perhaps, forming an additional group, if necessary.

System Interconnections

Wherever possible, water agencies should pursue interconnections to increase redundancy and provide aid during an emergency situation.

Extraordinary Conservation

"Extraordinary" conservation would be required following an extreme catastrophic event such as an earthquake. In these situations, the only way demands can be met is by asking the public to implement extraordinary conservation measures such as halting all outside irrigation, limiting the frequency of bathing, etc. In the upper Watershed, outside uses account for nearly 70% of water use. Thus, this type of extreme conservation could reduce demands in the upper watershed by the same amount.

Optimize Outside Funding Opportunities

The watershed is encouraged to work together to maximize outside funding opportunities that provide the greatest overall benefit to the watershed.

References

EMWD 20010 Urban Water Management Plan
IEUA 2010 Urban Water Management Plan
MWDOC 2010 Urban Water Management Plan
2010 San Bernardino Valley Regional Urban Water Management Plan
WMWD 2010 Urban Water Management Plan
SAWPA – Maps from Various Documents
SAWPA 2002 IRP, One Water One Watershed

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Document 9

CALIFORNIA
ENERGY
COMMISSION

California's Water – Energy Relationship

FINAL STAFF REPORT

Prepared in Support of the 2005 Integrated Energy Policy Report Proceeding (04-IEPR-01E)

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Arnold Schwarzenegger, *Governor*

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EXECUTIVE SUMMARY

As California continues to struggle with its many critical energy supply and infrastructure challenges, the state must identify and address the points of highest stress. At the top of this list is California's water-energy relationship: water-related energy use consumes 19 percent of the state's electricity, 30 percent of its natural gas, and 88 billion gallons of diesel fuel every year – and this demand is growing.

As water demand grows, so grows energy demand. Since population growth drives demand for both resources, water and energy demand are growing at about the same rates and, importantly, in many of the same geographic areas. This dynamic is exacerbated by the fact that Northern California has two-thirds of the state's precipitation while two-thirds of the population resides in Southern California. Water demand and electricity demand are growing rapidly in many of the same parts of the state stressing already constrained electricity delivery systems. When electric infrastructure fails, water system reliability quickly plummets and threatens the public health and safety.

The state water plan concludes that the largest single new supply available for meeting this expected growth in water demand over the next 25 years is water use efficiency. The remainder must be provided by the development of new water supplies including water recycling, and desalination of both brackish and seawater[1], all of which will increase energy demand over current levels.

Worse, the times when the highest energy intensity water supply options will be most needed are most likely to occur during multi-year drought periods when surface water supplies are low and groundwater levels drop, requiring even more energy for pumping each gallon of water. To compound the problem, reduced surface water supplies and snowpack in high elevations are likely to reduce the availability of valuable hydroelectric supplies. Yet, these are also the times when the most aggressive water conservation efforts are implemented, reducing overall water use, which helps reduce the total impact on energy demand. Although the net effects of this dynamic are not fully understood, this report presents current knowledge to assist with further analysis.

This is an urgent time of both challenge and opportunity. The primary finding of this paper is that a major portion of the solution is closer coordination between the water and energy sectors. A meaningful solution cannot be reached in the current regulatory environment where water utilities value only the cost of acquisition, conveyance, treatment, and delivery; wastewater utilities value only the cost of collection, treatment, and disposal; electric utilities value only saved electricity; and natural gas utilities value only saved natural gas. The state must both develop and expand best practices and existing programs to realize the substantial incremental benefits of joint water and energy resources and infrastructure management.

1 State Water Plan, B160-05.

While many nuances of this complex statewide problem are still unclear, staff's analysis shows that significant energy benefits can be reaped through the twin goals of the efficient use of water by end users and the efficient use of energy by water systems. It is also clear that not nearly enough has been done to ensure that California's water supply strategies are synchronized, hand-in-hand, with its energy strategies. Nor has enough been done to forge partnerships between the water and energy sectors so that their natural synergies, joint resources, and assets can be effectively leveraged for the benefit of all Californians.

The state has the opportunity now to reap near-term energy benefits by helping California's water and wastewater utilities become more energy self-sufficient, which will ease pressures on California's already stressed electric system. By adjusting existing policies, programs, and resources, water and wastewater utilities could be converted from high energy users to net renewable energy producers.

California's water and energy policymakers need to commit today to the joint planning and management of these critical resources. The state's water plan and resource strategies are being reviewed with all key stakeholders, and implementation plans are already on the drawing table. At the same time, the California Public Utilities Commission has approved substantial utility ratepayer expenditures in energy efficiency programs for the 2006-2008 program cycle. The state must waste no time in taking advantage of these rapidly evolving events.

The state can meet energy and demand-reduction goals comparable to those already planned by the state's investor-owned energy utilities for the 2006-2008 program period by simply recognizing the value of the energy saved for each unit of water saved. If allowed to invest in these cold water energy savings, energy utilities could co-invest in water use efficiency programs, which would in turn supplement water utilities' efforts to meet as much load growth as possible through water efficiency. Remarkably, staff's initial assessment indicates that this benefit could be realized at less than half the cost to electric ratepayers of traditional energy efficiency measures.

This staff report examines how energy is used – and how it can be saved – in the water use cycle. The strategies and goals for a comprehensive statewide water-energy program would achieve incremental energy benefits for water and energy utilities. The overarching goal of establishing a comprehensive statewide water-energy program would create a dynamic, living process where key stakeholders have incentives to continuously identify and implement strategies optimizing the state's water and energy resources and assets on an integrated, coordinated, and collaborative basis. This opportunity must not be lost since the need is so great. Because of all these factors, staff recommends that an action-oriented approach structured to achieve near-term results be developed immediately.

INTRODUCTION

The California Energy Commission's (Energy Commission) *California's Water Energy Relationship* staff report is part of the *Integrated Energy Policy Report* (*Energy Report*) proceeding. It was prepared to promote greater understanding of the critical symbiotic relationship between the water and energy sectors, especially electricity. In its scoping order, the Energy Commission stated that:

- "(f)or 2005, the Committee will continue the emphasis from the *2003 Energy Report* on increasing the level of energy efficiency and diversity in the state's energy systems and understanding the limitations of the state's electricity, natural gas, and transportation fuel infrastructure." [2]
- "The need for new water supplies in California and the West due to population growth and potential changes in the state's hydrological cycle has important implications for the state's energy system that are not yet fully understood. The *2005 Energy Report* will need to evaluate this issue as part of pursuing the broader goal of sustainability.[3]
- "To meet the challenge of sustainability, California's energy and environmental agencies, along with key private and public stakeholders, must work together to address critical issues that include:

    > Impacts of water demand and supply strategies, including the need for increased pumping to provide reliable water supplies, increased need for water treatment, and possible development of desalination facilities..."[4]

This report examines the dynamic give-and-take relationship between California's water and energy resources. Among many other issues, this staff report examines the state's water sector and its energy use, along with changes likely to occur in the future. The staff considered various components of the system and the energy implications, or characteristics of these components, for both energy use and generation. With the participation of a broad base of key stakeholders, the staff evaluated actions and methods that can boost the synergistic efficiencies of both the energy and water sectors. This report is meant to inform and provide technical support for decision makers, water and energy industry professionals, and the general public about critical energy supply and demand issues plaguing the state's water sector today.

[2] California Energy Commission, Integrated Energy Policy Report Committee Scoping Order, dated September 3, 2004, p. 2.
[3] Ibid.
[4] Ibid, p.7.

This study presents the best, most updated available information on linkages between California's energy and water sectors. The process to develop this report included two public workshops, several meetings of an ad hoc working group[5] formed for the study, and interviews with scores of water professionals. This outreach included two meetings with members of the Association of California Water Agencies, which represents about 90 percent of the state's water agencies (many of which also operate wastewater treatment facilities), members of the California Municipal Utilities Association, and participation in the annual plenary of the California Urban Water Conservation Council.

The following key concepts form the basis of the analysis in this paper:

- ***Water and energy relationship:*** Refers to the types and magnitude of water and energy interdependencies requiring documentation and evaluation for various types of water resources, end uses, systems, and processes in order to fully understand the water-energy tradeoffs under different resource planning scenarios. In this report staff uses ***water and energy utilities*** when encompassing all water, wastewater, electricity, natural gas, and diesel fuel suppliers, utilities, and districts, both public and private.

- ***Water use cycle:*** Refers to the overall process of collecting, developing, conveying, treating, and delivering water to end users; using the water; and collecting, treating, and disposing of wastewater.

- ***Energy intensity:*** Energy intensity is defined as the amount of energy consumed per unit of water to perform water management-related actions such as desalting, pumping, pressurizing, groundwater extraction, conveyance, and treatment - for example, the number of kilowatt-hours consumed per million gallons (kWh/MG) of water. This concept is applied to water supplies, to components of the water use cycle, and to the total energy intensity of a unit of water throughout the entire water use cycle.

- ***Energy self-sufficiency:*** Refers to an entity that supplies its own energy requirements. This would typically be done through a combination of energy efficiency and self-provision of power, whether purchased or produced.

- ***Integrated water and energy resource management:*** Refers to the comprehensive body of policies, practices, methods, tools, and procedures

[5] The Water-Energy Relationship Working Group consists of representatives from state water and energy-related government agencies, local and regional water agencies, industry organizations, environmental and citizen groups, and other key water professionals. It was established to help guide and critique this Staff Paper, but its life is expected to extend beyond the WER study process to work on other planning efforts, such as DWR's Water Plan process, and perhaps a planning effort related to optimization of pumped-storage opportunities in the state. The transcripts of all Water-Energy Relationship Working Group meetings on pumped-storage will be made available to the public and will become part of the record of evidence for the 2005 Energy Report.

that collectively comprise “statewide integrated water and energy resource planning and management.” Appendix A summarizes most of the existing organizations, programs, and research. Optimal integration is presently beyond the reach of both water and energy resource management best practices.

Chapter 1 describes California’s water-energy relationship – what it is and what it means within the context of California’s current energy circumstances. Chapters 2, 3, and 4 examine the primary components of the entire water cycle and address their energy intensity. Chapter 5 discusses the potential development of new renewable energy resources by water and wastewater utilities. Chapter 6 explores different types of future changes likely to affect the energy intensity of water supplies; water treatment and distribution; water end use; and wastewater treatment and disposal. Findings and recommendations are contained in Chapter 7. Appendices appearing at the end of the report provide additional detail, and a glossary of terms is included.

CHAPTER 1 - WHAT IS THE WATER-ENERGY RELATIONSHIP?

The nation's water and energy resources are inextricably entwined. Energy is needed to pump, treat, transport, heat, cool, and recycle water. On the flip side, the force of falling water turns the turbines that generate hydroelectric electricity, and most thermal power plants are dependent on water for cooling. In California, an elaborate system of manmade storage, treatment and conveyance structures exist to augment natural hydrologic features. This system not only helps produce needed electricity supplies but requires large amounts of energy to deliver quality water where Californians need and want it.

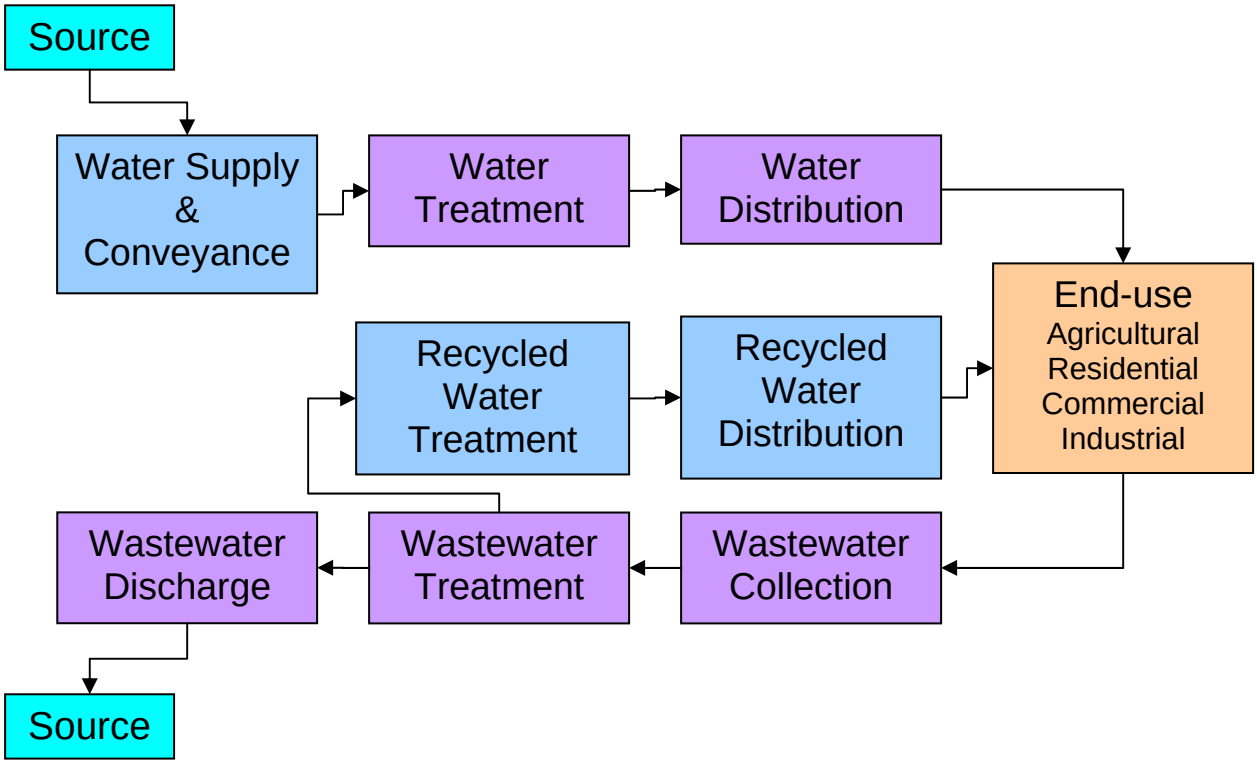
This chapter describes the overall water use cycle and introduces the concept of energy intensity. The energy intensity framework in the water use cycle helps identify opportunities for changing the pattern and magnitude of water-related energy consumption in California.

The Water Use Cycle

The Water-Energy Relationship Working Group discussed the state's water use cycle at length. While there are exceptions, Figure 1-1 illustrates the state's typical cycle.[6] Turquoise blue represents sources of water, water supplies are shown in light blue, water and wastewater treatment are shown in purple, and end use is shown in beige.

[6] This schematic is based on work by Dr. Robert Wilkinson (Wilkinson, Robert C., 2000. *Methodology For Analysis of The Energy Intensity of California's Water Systems, and an Assessment of Multiple Potential Benefits Through Integrated Water-Energy Efficiency Measures*, Exploratory Research Project, Ernest Orlando Lawrence Berkeley Laboratory, California Institute for Energy Efficiency) and on Wilkinson and Gary Wolff in current work on the energy intensity of water in California with additions by Energy Commission staff.

Figure 1-1: California's Water Use Cycle



Water is first diverted, collected, or extracted from a source. It is then transported to water treatment facilities and distributed to end users. What happens during end use depends primarily on whether the water is for agricultural or urban use. Wastewater from urban uses is collected, treated, and discharged back to the environment, where it becomes a source for someone else. In general, wastewater from agricultural uses does not get treated (except for holding periods to degrade chemical contaminants) before being discharged directly back to the environment, either as runoff to natural waterways or into groundwater basins. There is a growing trend to recycle some portion of the wastewater stream – recycled water – and redistributing it for non-potable end uses like landscape irrigation or industrial process cooling.

Water-Related Energy Use

Energy is required at all stages of the water use cycle. It is difficult to measure the amount of water-related energy that is actually consumed. Better information is available about energy consumption by water and wastewater utilities. However,

energy consumption by water users is harder to determine since electric and gas meters do not separately measure water-related uses.[7]

The data presented in Table 1-1, with supporting details in Appendix B: 2001 California Energy Consumption by End Use, are based on information provided by the state's energy utilities to the Energy Commission for use in demand forecasting.[8] The Water-Energy Relationship Working Group and other stakeholders participated in extensive discussions to help staff estimate the magnitude of water-related energy consumption by water and wastewater utilities, and agricultural and urban water end users. As shown in Table 1-1, these estimates indicate that total water-related consumption is large – 19 percent of all electricity used in California, approximately 30 percent of all natural gas, and more than 80 million gallons of diesel fuel. The Energy Commission is funding a research project to refine the numbers, and results are expected in early 2006.

Table 1-1: Water-Related Energy Use in California in 2001

	Electricity (GWh)	Natural Gas (Million Therms)	Diesel (Million Gallons)
Water Supply and Treatment			
Urban	7,554	19	?
Agricultural	3,188		
End Uses			
Agricultural	7,372	18	88
Residential	27,887	4,220	?
Commercial			
Industrial			
Wastewater Treatment	2,012	27	?
Total Water Related Energy Use	**48,012**	**4,284**	**88**
Total California Energy Use	**250,494**	**13,571**	?
Percent	**19%**	**32%**	?

Source: California Energy Commission

The data in this table have been organized to align with the water use cycle in Figure 1-1. Water supply and treatment corresponds to the part of the water use

[7]Meters are typically installed to record all the electricity or natural gas use by an entire household, building or other type of facility.
[8] Agricultural data in this table is taken from Tables 1-4 and 1-5 in this chapter.

cycle between the source and end-user. Water supply and treatment account for 22 percent of water-related electricity consumption; 70 percent is required by urban water users and 30 percent by agriculture. On-farm agricultural water use consumes additional energy, estimated at 15 percent of water-related electricity demand. Residential, commercial, and industrial end uses combined represent 58 percent of the electricity consumed. Wastewater treatment accounts for 4 percent. The vast majority of water-related natural gas consumption is by residential, commercial, and industrial customers, primarily for heating water. Natural gas consumption in the agricultural sector is primarily for irrigation pumping. Agriculture is the only sector where diesel fuel consumption, which is also used for water pumping, is quantified. Question marks in the table indicate areas where additional information is needed.

The Energy Intensity of the Water Use Cycle

Each element of the water use cycle has unique energy intensities (kilowatt hours/million gallons (kWh/MG)). Table 1-2 illustrates the considerable variability in both the range of intensities for each segment and the components of the water use cycle. End use energy demand was excluded since the focus is on the energy requirements in the remaining conveyance, treatment, distribution, and wastewater treatment processes. Details supporting this table are in Appendix C: Energy Impact Analysis of Existing Water Management Practices.

Table 1-2: Range of Energy Intensities for Water Use Cycle Segments

	Range of Energy Intensity kWh/MG	
Water-Use Cycle Segments	**Low**	**High**
Water Supply and Conveyance	0	14,000
Water Treatment	100	16,000
Water Distribution	700	1,200
Wastewater Collection and Treatment	1,100	4,600
Wastewater Discharge	0	400
Recycled Water Treatment and Distribution	400	1,200

<u>Water Supply and Conveyance</u>

Energy intensity for this portion of the water use cycle is determined primarily by the volume of water that is transported, the distance, and the changes in topography along its route. California's water supply varies significantly with annual and seasonal hydrologic conditions, and with climate, geography, and topography. Nearly 70 percent of the state's total stream runoff is north of Sacramento, but 80

percent of the water demand is south of Sacramento. This creates challenges that policymakers have struggled to resolve for nearly a century.

The energy intensity of collection, extraction, and conveyance of raw water supplies can be near zero for gravity-fed systems from the Sierra to both urban areas in Northern California and agricultural districts in the Central Valley. However, other systems use very large pumps to transport large volumes of water hundreds of miles from points of collection to points of need. As a consequence, the energy intensity of water supplies in Central and Southern California is typically much higher than in Northern California, with Southern California the highest due to the need to transport water more than 3,000 feet up over the Tehachapi Mountains.

Water Treatment

Some sources of water need very little treatment, so their energy intensity is low. Other sources, such as brackish groundwater or seawater desalination, require much more treatment so their energy intensity is significantly higher. The energy intensity also varies depending on the intended end user. For example, most agricultural and some industrial end users can use water that requires little or no treatment, while most residential and commercial users need water treated to potable standards.

Energy use for water treatment will increase as more stringent water quality rules are implemented under the Safe Drinking Water Act and the Clean Water Act. These new rules require multi-stage disinfection - including treating potable water more than once to ensure the removal of harmful organisms that may grow during storage and transport - and improved disinfection technologies that reduce risk of carcinogens and other potentially harmful disinfection by-products. These improved disinfection technologies – principally, ultraviolet treatment and ozonation – are much more energy intensive than prior chemical methods.[9]

Water Distribution

Some fresh water distribution systems are gravity fed, but most require some pumping. The primary driver of increased energy for water distribution is urban growth.

Wastewater Collection

Some wastewater collection systems use gravity to bring the wastewater to a treatment plant. Others need energy to lift or transfer the wastewater.

Wastewater Treatment

All wastewater treatment systems require energy, though some require more than others depending on the quality of the waste stream, the level of treatment required, and the treatment technologies used. Energy use for wastewater treatment is expected to increase with adoption of more stringent water quality rules under the

[9] There may be some energy savings that are not considered here due to the reduction in needed chemicals for treatment.

Clean Water Act. However, by increasing the quality of wastewater effluent, more recycled water can be added to the state's water supply portfolio.

Wastewater Discharge
Some wastewater discharge systems use gravity to return wastewater to the environment. Others need energy to lift or transfer the wastewater.

Recycled Water and Distribution
Depending upon the level of wastewater treatment in existing facilities, the effluent may be recyclable without requiring additional treatment to displace potable water sources used for non-potable applications. More energy is needed if additional treatment is required. Most recycled water distribution systems require additional energy to pump water uphill to intended users.

As noted previously, since there are so few options to make new water, the increased use of recycled water is a major strategy in the state's water plan.

Energy Intensity in Northern and Southern California

Due to significant variations in energy used to convey bulk water supplies from one place to another, the average energy intensity of the water use cycle in Southern California is much higher than in Northern California. This is due to the fact that Southern California imports about 50 percent of its water supplies from the Colorado River and from the State Water Project (SWP) – each of which is more energy intensive than any single source of water supply used in Northern California.

Table 1-3 shows the combined energy intensity of the water use cycle for typical urban communities in Northern and Southern California. Details supporting this table can be found in Appendix C.

Table 1-3: Electricity Use in Typical Urban Water Systems

	Northern California kWh/MG	Southern California kWh/MG
Water Supply and Conveyance	150	8,900
Water Treatment	100	100
Water Distribution	1,200	1,200
Wastewater Treatment	2,500	2,500
Total	3,950	12,700
Values used in this report	4,000	12,700

Staff recognizes that no two water treatment, distribution, or wastewater treatment systems are identical, so the relative energy intensities reflected above are prototypical. However, within these processes, variability is lower in magnitude than with conveyance and is not linked to a north/south differentiation. The primary north/south regional variation that causes the state's unique and important water energy dynamic is linked to the magnitude of energy required to convey Northern California water supplies to Southern California.

On average, water conveyance requires more than 50 times the energy for Southern California than it does for Northern California. This is also five times the national average. Southern California depends heavily on water imports from the Colorado River and from Northern California. This water travels hundreds of miles through pipelines and aqueducts and, in some places, must be pumped over mountain ranges before reaching its destination. Conversely, 40 percent of Northern California's population is served by gravity-fed systems, with the balance supplied by surface supplies or relatively shallow wells. Recognizing that the actual energy intensity in each component of the water use cycle will vary by utility, the energy values reflected above appear to be reasonable and conservative. This paper assumes that 4,000 and 12,700 kWh per million gallons are consumed for water that is supplied, treated, consumed, treated again, and disposed of in Northern and Southern California, respectively.

Water End Use Energy

California uses about 14 trillion gallons of water in a normal year, with about 79 percent used for agriculture and the remainder in the urban sector. Once water is delivered, customers use it in a variety of applications. Combined agricultural, residential, commercial, and industrial water-related end uses account for 58 percent of all water-related electricity and 99 percent of water-related natural gas use.

Agriculture

Agricultural water use can be both energy intensive, requiring extensive pumping and, in some cases, treatment; but it can also be essentially energy-free, using gravity alone to flow raw surface water onto fields. Each year, California's agricultural sector uses roughly 34 million acre-feet of water to grow food and fiber commodities. It takes more than 10,000 GWh of electrical power to pump and move this water. The energy is used by large state and federal water projects, by irrigation districts, and by on-farm requirements, as outlined in Table1- 4 below.

Table 1-4: Energy Consumed in Agriculture for Water

Category	Energy Consumption (GWh)[1]
Conveyance to Irrigation Districts by the State and Federal water projects[2]	1,720
Conveyance to Irrigation Districts by the Western Area Power Administration	400
Irrigation District surface water pumping	822
Irrigation District ground water pumping	246
On-farm ground water pumping	4,499
On-farm booster pumping[3]	2,873
Subtotal	10,560
Electric equivalent for diesel and natural gas engine driven water pumping[4]	1,231
Total	11,791

[1]Values shown in this table only include agricultural water pumping to meet crop applied water demands. Other agricultural water uses not included in this table include water used for livestock and food processing that is not considered to be commercial. Source: California Agricultural Water Electrical Energy Requirements, ITRC Report No. R 03-006, Irrigation Training and Research Center, 2003 http://www.itrc.org/reports/cec/energyreq.html

[2] Energy used to pump surface water through state and federal water projects to supply irrigation and water districts.

[3]This includes groundwater and surface water pumping to supply pressurized irrigation systems such as sprinkler, drip, and micro spray.

[4]Diesel and natural gas are the second and third most prevalent energy sources used to pump agricultural water. These sources are used to run engines that directly run the water pumps, typically for on-farm groundwater and booster pumping. Emissions requirements typically prevent the use of diesel for pumping in irrigation districts.

The numbers in Table 1-4 represent energy consumption for a typical weather or water year. These numbers will change with different water year scenarios. For example, during a wetter-than-average year with larger surface water deliveries, the energy used for groundwater pumping will decrease. During a period of several back-to-back dry years, a significant amount of additional energy will be used because of increased on-farm groundwater pumping.

In general terms, the electricity used for water represents more than 90 percent of the total electricity used for crop production in the agricultural sector. This applies mostly to field crops, but also to the state's fruit and nut trees and vineyards.

Dairy farms use electricity and other fuels for pumping water for crops, heating water for cleaning and disinfecting barns, and transporting wastewater for lagoon disposal and aerators. Most of the remaining electricity is used for milking equipment and refrigeration. Fans are also used for animal cooling. Greenhouses and nurseries use electricity and other fuels for watering crops, ventilation, and heating. Other agricultural on-farm electricity use goes to food processing including washing, packaging, and refrigeration. However the majority of food processing is in large-scale processing facilities typically classified as industrial. Their energy requirements are discussed in the section describing industrial water users.

Although most agricultural electricity use is during the summer months, there are many year-round operations including dairies, nurseries and greenhouses, feedlots, and other animal production farms.

As shown in the previous table, diesel and natural gas are also used to pump water. Table 1-5 provides an estimate of the breakdown between diesel and natural gas used for agricultural water use in California (Cal Poly 2003).

Table 1-5: Estimates for Diesel and Natural Gas Engine Driven Water Pumping in California Agriculture

Type	Number of Engines[1]	Fuel Required	Conversion to kWh[2]	Equivalent Electricity (GWh)
Natural Gas	1,932	17.5 Million Therms	6.76 kWh/Therm	118
Diesel	12,535	88 Million Gallons	12.8 kWh/gallon	1,113
Totals	14,467			1,231

[1] These data were generated by Cal Poly ITRC during the analysis for the *California Agricultural Water Electrical Energy Requirements Report* (2003). However, it was not published in that report (Cal Poly ITRC unpublished data, 2005). It was subsequently submitted as testimony in the June 21, 2005, IEPR workshop.
[2] The total number of diesel-and natural gas-engine-driven water pumps was obtained from the 2003 USDA Farm and Ranch Irrigation Survey. In comparison, the estimate used for the 2005, AG-ICE proceeding with the CPUC (A.04-11-007/008) provided by the California Air Resources Board (CARB) reported about 8200 diesel driven irrigation pumps. The estimate from CARB is low compared to the USDA survey. We chose the USDA data because they survey more farms throughout California [http://www.nass.usda.gov/census/census02/fris/tables/fris03_20.pdf].
[3] The conversion from kWh to therms and gallons of diesel is based on the Nebraska Performance Standards for Irrigation Energy Sources (Source: Dorn, T.W., P.E. Fishbach, D.F. Eisenhauer, J.R. Gilley, and L.E. Stateson, *It Pays to Test Your Irrigation Pumping Plant*. Publication EC-713. Lincoln: University of Nebraska, Cooperative Extension Service).

Changes to air quality regulations in agricultural regions will likely lead to conversion of many of these pumps, primarily the diesel-powered ones, to electric pumps. If they were all converted to electric, this would increase the electric requirements of

the agricultural sector by more than 10 percent. Although the total number of potential conversions is limited by regulation and available program incentives, the state's planners and electric utilities will need to account for and supply the additional peaking capacity and electricity needed for these pumps. This is discussed in more detail in Chapter 4.

Residential, Commercial and Industrial

Staff has only recently focused on water-related energy consumption in the residential, commercial, and industrial sectors, collectively referred to as urban water users. Table 1-6 presents the aggregated data for each sector. Detailed information can be found in Appendix B.

Table 1-6: End-Use Energy Associated with Urban Water Users

Sector	Electricity (GWh)	Natural Gas (Million Therms)
Residential	13,528	2,055
Commercial	8,341	250
Industrial	6,017	1,914
Total	**27,887**	**4,220**

Source: California Energy Commission

The residential sector accounts for 48 percent of both the electricity and natural gas consumption associated with urban water use. Residential water uses include personal hygiene (shower, bath, sink), dish and clothes washing, toilets, landscape irrigation, chilled water and ice in refrigerators, and swimming pools and spas. Residential energy uses related to these activities include water treatment (filtering and softening), heating (natural gas or electric water heaters), hot water circulation loops, cooling (icemakers and chilled water systems for HVAC and chilled drinking water), circulation (spa pumps, as one example), and, in some cases, the groundwater pumping of private wells.

Commercial water-related energy use represents 30 percent of the electricity and 6 percent of the natural gas use. Industrial water-related energy use represents 22 percent of the electricity and 45 percent of the natural gas. Commercial and industrial water uses include all those found in residences, plus hundreds more. Some of the more energy-intensive applications related to commercial or industrial water use include high-rise supplemental pressurization to serve upper floors, steam ovens and tables, car and truck washes, process hot water and steam, process chilling, equipment cooling (x-ray machines, for example), and cooling towers. In the commercial sector, the major water-related end uses that use electricity are cooling and water heating. Cooling towers for air conditioning are large water users. In the industrial sector, water-related energy use is very dependent upon specific processes. Except for oil and gas extraction, no single industrial category stands out

as a major user of electricity or natural gas. Water heating and process heating are the largest users of natural gas.

In general, urban water use in California is more energy intensive than agricultural water use. This is because every urban water system requires energy for water and wastewater treatment, both of which are not generally required for agriculture. The vast majority of urban water systems also require energy for distribution.

Hydropower Production, Energy Recovery, and Renewable Resources

Hydropower

The most widely recognized aspect of the water-energy relationship is hydropower production. As discussed in Chapter 2, California is served by a vast system of reservoirs and dams, pumped storage, and run-of-river facilities. These facilities are operated by investor-owned utilities (IOU), publicly owned utilities (POU), state and federal agencies, irrigation districts, and other entities, mostly to serve multiple purposes including power generation, water supply, recreation, and flood control. California's hydropower system provides valuable peaking reserve capacity, spinning reserve capacity, load following capacity, and transmission support, all at low production costs.[10] California's combined total hydroelectric capacity is more than 14,000 megawatts (MW)[11] or about one-quarter of the in-state generation capacity. Hydro-generated energy was about 29,000 GWh, or 13 percent of the in-state generation in 2004.[12] The state has conducted extensive studies on traditional hydropower, both in the contexts of its value to the California electric system and issues relating to environmental impacts. Staff refers the reader to these existing reports reference herein, all of which are available on the Energy Commission's Web site.

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[10] California Energy Commission Staff Report, *California Hydropower System: Energy and Environment*, Appendix D, *2003 Environmental Performance Report*; prepared in support of the Electricity and Natural Gas Report under the Integrated Energy Policy Report Proceeding (02-IEP-01), October 2003 [Publication 100-03-018].

[11] California Energy Commission, *2003 Environmental Performance Report*. Appendix D, *California Hydropower System: Energy and Environment*, Sacramento, CA. 100-03-018, March 2003, p. D-6.

[12] California Energy Commission, *Potential Changes in Hydropower Production from Global Climate Change in California and the Western United States*, June 2005, consultant report, Prepared in support of the *2005 Integrated Energy Policy Report*, Publication No. CEC 700-2005-010.

Energy Recovery from the Water Use Cycle

In-Conduit Hydropower

The state's large water conveyance projects already take advantage of the energy in the water flowing through their pipelines. Wherever there is flowing water, there exist both energy and the potential to capture and utilize that energy. Pipelines that convey water supplies by gravity have energy that could be captured, but care must be taken to make sure that sufficient 'head', or force, remains to carry the water to its final destination. Wherever pressure-reducing valves or stations are used to reduce the energy in moving water, there is an opportunity for energy production. At any point in a water or wastewater system where influent is delivered for treatment or wastewater effluent is discharged, there may be further opportunities for power production. Barriers and challenges to additional development of in-conduit hydropower that recovers energy from the water delivery and conveyance process are discussed in more detail in Chapter 5.

Biogas

Another option for developing generation in the water sector is to increase beneficial use of digester gas produced by the sewage wastewater, dairy manure, and food processing wastes/wastewater. Biogas, composed primarily of methane, can be used for combined heat and power (CHP) production.

California has 311 sewage wastewater treatment facilities, 2,300 dairy operations, and 3,000 food processing establishments. Currently, about 50 percent of sewage sludge, 2 percent of dairy manure, and less then 1 percent of food processing wastes/wastewater generated in the state are used to produce biogas. Converting these wastes into energy can help operating facilities offset the purchase of electricity and provide environmental benefits by reducing discharged air and ground water pollutants.

The Energy Commission is working with Commerce Energy Inc. and Inland Empire Utility Agency (IEUA) to develop technologies that will address the lack of knowledge of the relationship between various co-digestion feedstocks (sewage sludge, food processing wastes, and dairy manure) and gas production.

Other Renewable Energy Resources

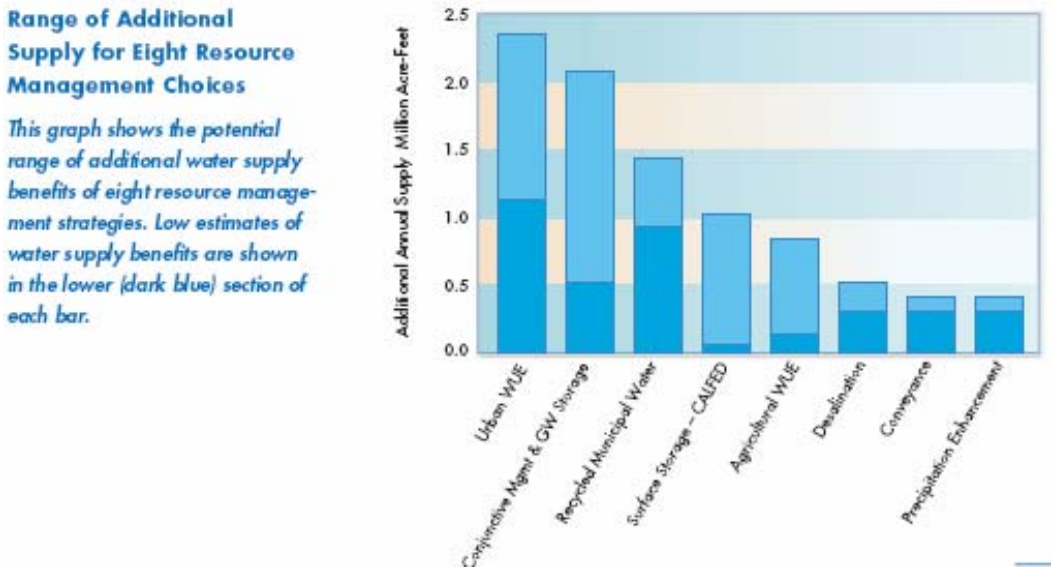
Water and wastewater agencies typically have very large landholdings with characteristics that readily lend themselves to the development of renewable resources, especially wind and solar. These resources could be used to help California meet its aggressive Renewable Portfolio Standard (RPS) goals. For example, regional water and wastewater agencies have hundreds of miles of rights-

of-way, often in areas suitable for solar production. These agencies also have watershed lands that collect water for end-use applications, either potable or for agricultural or industrial use. In order to protect the water quality, large portions of these watershed lands are inaccessible to public recreational use. Many are remotely located, which make their visual impact of little public concern. Watershed lands are also at higher elevations, where wind resources are typically of fairly good quality. Some wastewater utilities also have extensive lands, which are used to dispose of treated effluent and are inaccessible to the public. Municipal or governmental control over these lands could accelerate their use as sites for renewable energy generation

A Loading Order for Water Resources

The *California Water Plan Update 2005,* prepared by the Department of Water Resources (DWR), established a strategic plan that prioritized resource measures to meet new load growth and other water supply challenges. As shown in Figure 1-2, first among the strategies is increased urban water efficiency. Appendix D provides an excerpt of the plan from the Water Plan Update. Thereafter, the plan depends upon increased reliance on conjunctive management and groundwater, followed by recycled water. Agricultural water use efficiency is also an important strategy.

Figure 1-2: New Water Supplies for California



Source: *2005 State Water Plan Update*, DWR.

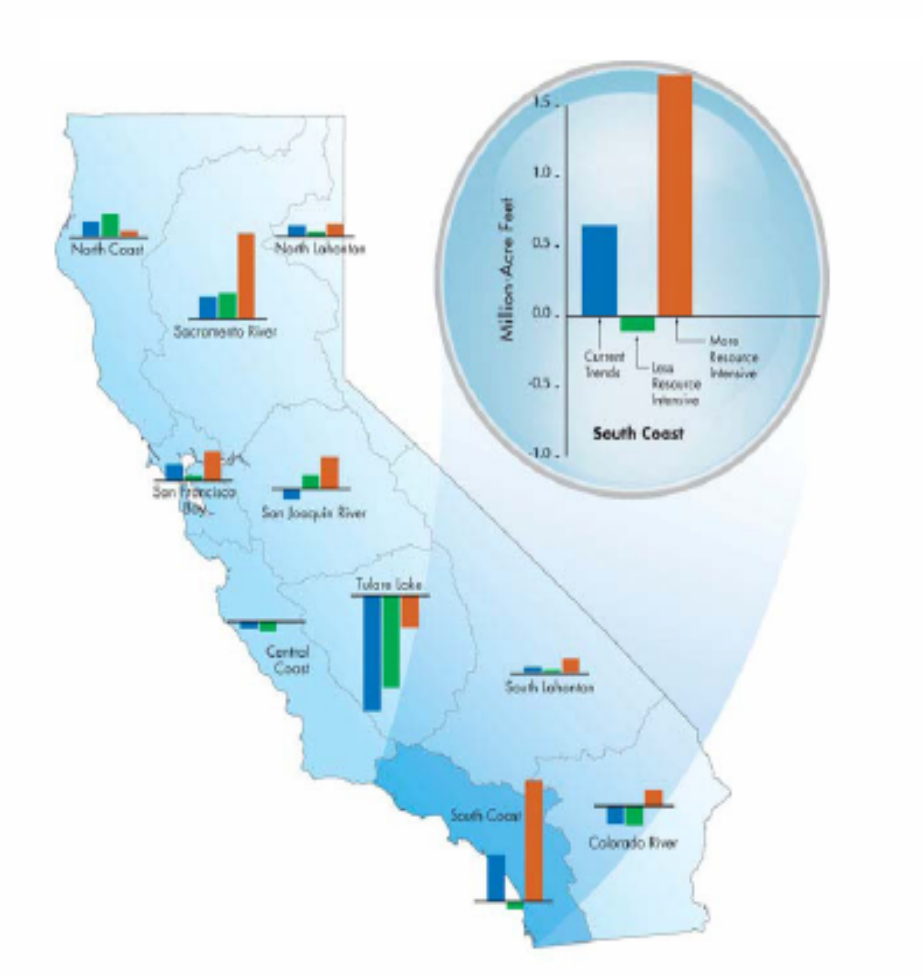
In many respects, the *2005 Water Plan Update* mirrors the state's adopted loading order for electricity resources described in the Energy Commission's *Integrated Energy Policy Report 2005* and the multi-agency *Energy Action Plan*. The first three

strategies all concern the efficient use of existing resources. These strategies encompass efficient use, efficient operations and management, and efficient reuse. Including agricultural water use efficiency, the state's water resources strategy targets will meet 70 percent of future growth in water demand through efficiency measures.

This is a very important concept. Specifically, like energy utilities, water utilities already apply integrated resource planning tools and techniques in their future plans. Similar to energy utilities, they also already apply strategies of "least-cost, best-fit." Thus, in order to optimize the state's water and energy resources on an integrated basis, the primary concept that needs to be integrated into California's water planning on the supply side is the energy intensity of various water supply options. On the demand side, the primary concept is recognition of the energy embedded in various types of water end use throughout the entire water use cycle. Just as energy efficiency increases available supplies and avoids incremental infrastructure costs and environmental impacts, every unit of water not consumed can displace a more energy-intensive water source.

In many cases, the areas of the state that are most stressed with respect to water supplies are also areas with transmission congestion and shortages of local energy supplies. Not surprisingly, since load growth is largely driven by population growth, the geographic areas most resource constrained are the same for both water and for energy. Figure 1-3 shows the projected water demand as estimated by DWR for three different future scenarios and demonstrates the sizable gap between the less and more water-resource-intensive projections. This makes a compelling case for close coordination between water and energy planning and synchronization of both resources and infrastructure goals.

Figure 1-3: Net Change in Average-Year Water Demand for 3 Scenarios by Region, 2000-2030

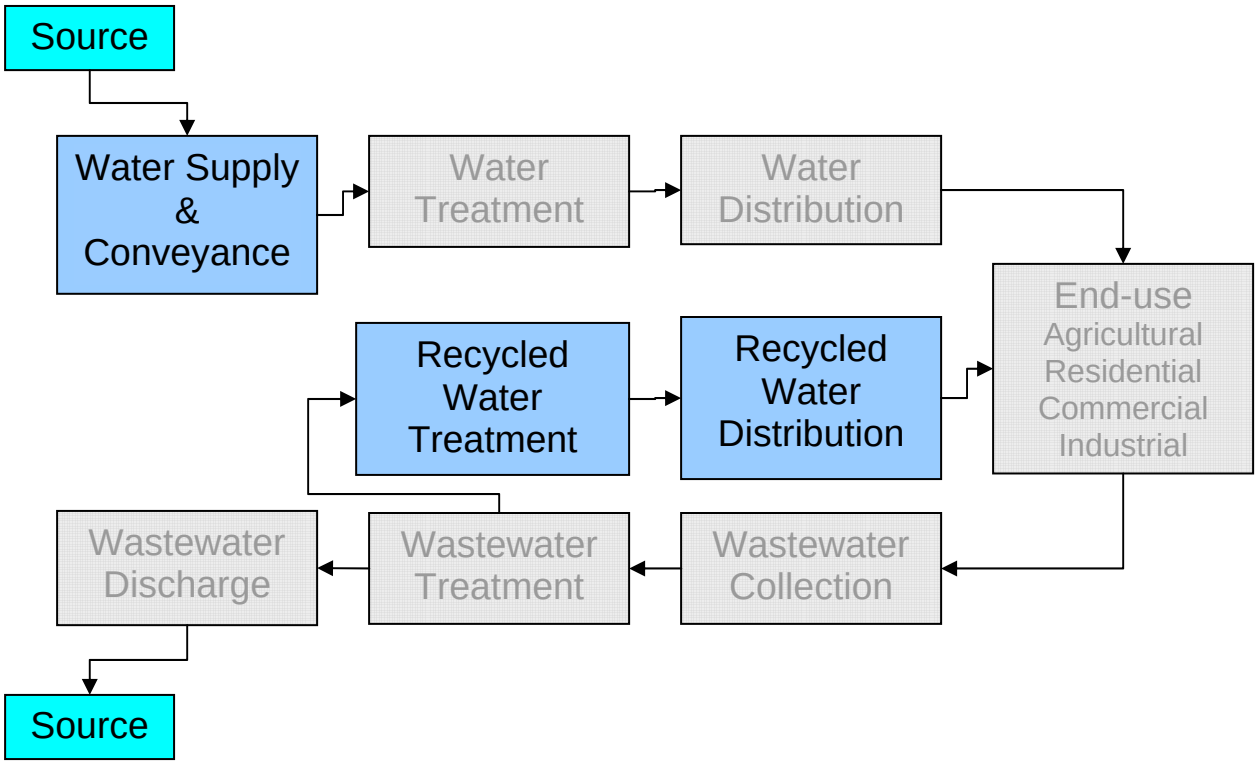


Source: *2005 State Water Plan Update*, DWR.

CHAPTER 2 – WATER SUPPLY AND CONVEYANCE

This section discusses the energy intensity of different water supply sources, all the way through the cycle to conveyance for water treatment. Recycled water, a by-product of wastewater treatment, is also discussed here as an additional source of supply.

Figure 2-1: Water Use Cycle - Supply Source



Primary Sources of California Water

Californians collectively use about 43 million acre-feet (about 14 trillion gallons) of developed water for urban and agricultural use in a normal year. Of this total, 34 million acre-feet go to agriculture (about 11 trillion gallons and 79 percent) and 9 million acre-feet (about 3 trillion gallons and 21 percent) go to the urban sector.[13]

Understanding the energy implications of water use in California requires a basic knowledge of the various water systems that collect, store, and transport water

[13] DWR *2005 Water Plan Update* Volume 1, Table 3-1.

supplies. These supplies can be roughly categorized as surface water, groundwater, desalted water, and recycled water.

- Surface water comes from precipitation, rain and snow, captured and stored in natural lakes and streams, and manmade reservoirs, canals or aqueducts. Most surface water storage is fed from runoff coming from the state's large mountain ranges. The greatest source of surface water supplies is the Sierra snowpack, which holds more water than all of the state's lakes and reservoirs put together, and conveniently melts during the warmer and drier months when California most needs water.

- Groundwater is precisely that – water stored in the ground. Rain directly irrigates farms and gardens but also feeds groundwater basins and aquifers.[14]

- Recycled water, also known as "reclaimed" water or "reuse", is water produced from wastewater effluent. Water quality regulations specify approved uses for recycled water. The level of use depends upon the level of wastewater treatment applied.

- Ocean or brackish water is used for some industrial purposes but must be treated to remove salts and dissolved solids (desalted) for agricultural and urban purposes.

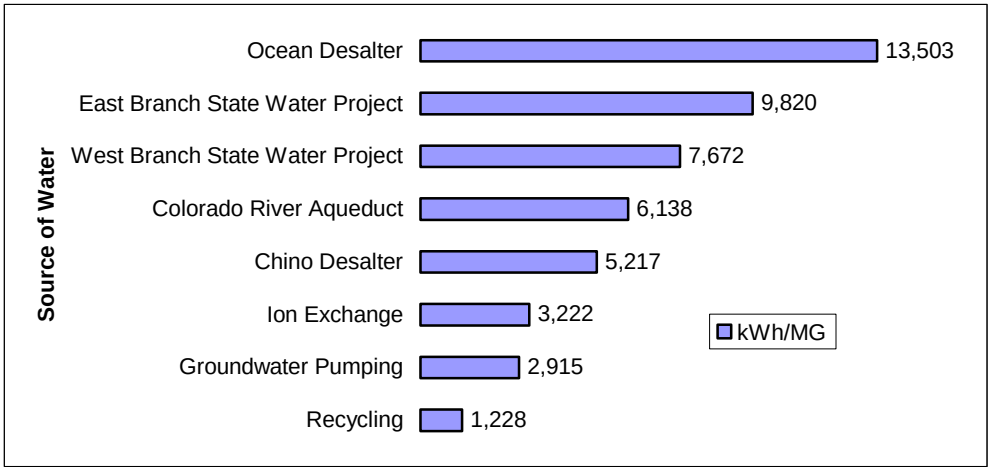
According to DWR's *2005 Water Plan Update*, surface water accounts for more than 60 percent of the state's water use in a typical hydrology year. Groundwater accounts for about 30 percent, although this is highly variable since groundwater makes up most of the state's water supply shortages in dry years. Use of desalted and recycled water, while still a very small percentage of California's total water supply portfolio, is increasing -- both as a means to supplement limited water supplies and provide a hedge against drought risk.

The Energy Intensity of Water Supplies

Every source of water has a different energy intensity. Figure 2-2 shows the relative energy intensity of water supply options for one Southern California regional water and wastewater utility, the Inland Empire Utilities Agency (IEUA).

[14] An aquifer is a body of permeable rock that can contain or transmit water.

Figure 2-2 Energy Intensity of IEUA Water Supply Options



Source: Dr. Robert Wilkinson, Environmental Studies Program, University of California, Santa Barbara, and Martha Davis, IEUA.

Of the above IEUA options, the East Branch State Water Project source is second only to ocean desalination in energy intensity. Recycled water is the least energy-intensive supply option. The relative energy intensity of supply options varies for each water utility, depending upon the nature and characteristics of its water supplies.

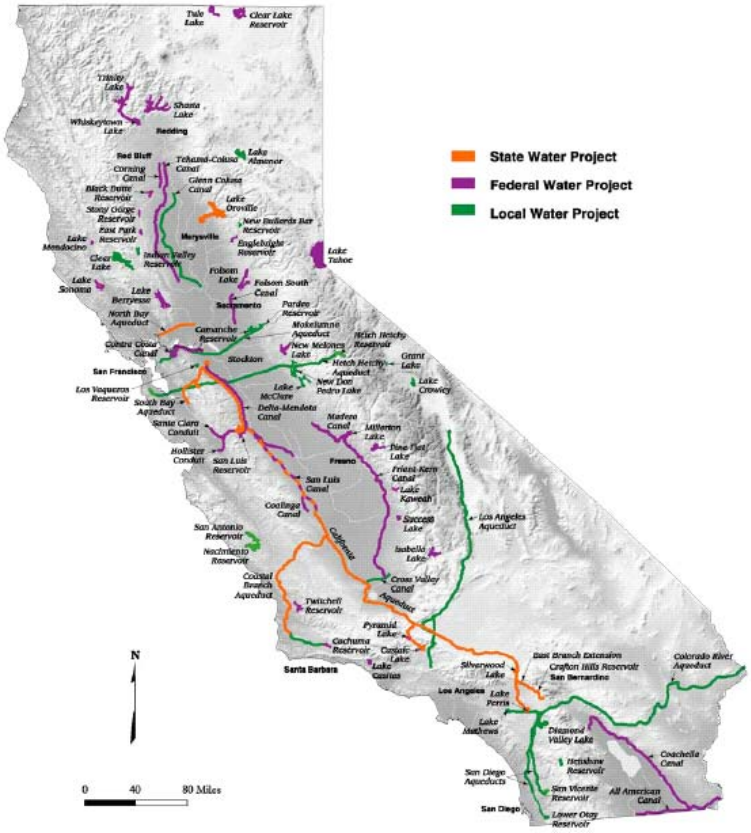
The sections below describe the relative energy intensities of various water supply sources. This concept is important to the discussions in the following chapters since the energy intensity of supply is the most significant sector in which near-term action can positively affect the state's energy circumstances.

Surface Water

The energy intensity of surface water supplies is mainly in the conveyance of raw water for either agricultural and some industrial uses or to treatment facilities for potable urban water use.

California's water supply varies significantly with annual and seasonal hydrological conditions, as well as geography and topography. The major water sources are in Northern California, while the major urban centers and agricultural lands are in the Northern Bay Area, Central Valley, and Southern California. Surface water conveyance systems were built to balance statewide water supplies with demands. These conveyance systems were designed to move water to areas of need outside the basin in which water is collected. This process – known as "interbasin transfers" – accounts for most of the energy embedded in California's surface water supplies. The energy intensity of various interbasin transfers depends on the distance and elevation over which the water must travel. The map in Figure 2-3 shows the state's interbasin transfer systems.

Figure 2-3 Interbasin Transfer Systems in California



Source: *2005 State Water Plan Update*, DWR.

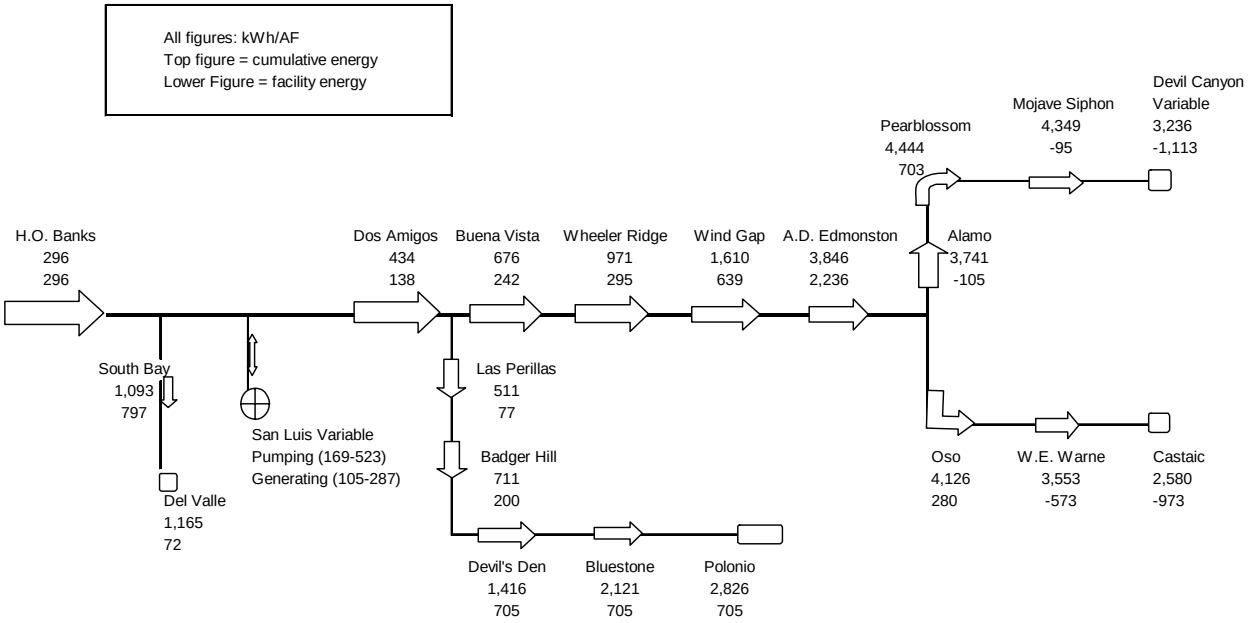
It is the pumping of this water that accounts for the relative energy intensities of different surface water sources. Note that some systems originate in mountain ranges and use gravity to naturally deliver water to points of need. These systems use very little energy. Other systems must transport water long distances on relatively flat valley floors. The State Water Project must also pump water more than 3,000 feet over the Tehachapi range to reach end users in Southern California.

SWP, the largest state-built multipurpose water project in the U.S., was planned, designed, built, and is now operated and maintained by the DWR. The SWP was constructed for the primary purpose of transporting water from Northern California to arid areas, both agricultural and urban, in Central and Southern California. The SWP delivers water to 29 water agencies and irrigation districts, which then distribute the

water to 20 million people and 900,000 acres of crops. SWP water is distributed about 50/50 to agricultural and urban water uses.[15]

The elevation diagram below (Figure 2-4) illustrates the relative energy intensity of delivered SWP water at various points along the California aqueduct. The numbers are shown in kilowatt-hours per acre-foot (kWh/AF). They include transmission losses and, where applicable, energy recovery.

Figure 2-4: State Water Project Pumping Energy



Source: Dr. Robert Wilkinson, PhD, University of California, Santa Barbara, based on DWR data.

Depending on the point at which SWP water is delivered, the embedded energy may range from a low of 676 kWh/AF (676 x 1,000,000 gallons/325,851 gallons/AF = 1,330 kWh/MG) at Dos Amigos, to a high of 3,236kwh/AF (9,930 kWh/MG) at Devil Canyon.

Many of the state's interbasin transfer systems also have significant hydroelectric generation. The Central Valley Project, the East Bay Municipal Utility District's (EBMUD) Mokelumne Aqueduct, and San Francisco's Hetch Hetchy Regional Water System, are all net energy producers. Despite its significant hydroelectric capacity, the State Water Project is a net energy consumer. The Colorado River Aqueduct is also a net energy consumer in California, although the project itself includes significant federal hydroelectric projects on the Colorado River.

[15] Presentation by Bill Forsythe, DWR, to Committee Workshop January 14, 2005.

Groundwater Sources

Groundwater supplies about 30 percent of the state's water needs on average but as much as 60 percent during times of severe drought.

Several hundred million acre-feet of water are stored in 450 groundwater aquifers in the state, compared with approximately 45 million acre-feet in California's 1,200 surface water reservoirs.[16] These aquifers are recharged either naturally or artificially. Natural recharge generally consists of runoff that percolates into the soil, or migration of surface water through a lake or streambed. Almost all of the 450 groundwater aquifers in the state are in decline or overdrafted, forcing users of that water to pump from greater and greater depths, requiring greater amounts of energy in the process.

The process of artificially storing groundwater for future withdrawal is known as aquifer storage and recovery (ASR). Closely related to ASR are "conjunctive use" and "artificial recharge," terms that are often used interchangeably. Water agencies around the state store water in aquifers for both daily and seasonal use and for emergency drought supplies. In general, surplus water is pumped into wells or allowed to percolate into aquifers from ponds and lakes, then pumped from wells when needed.[17]

Less is known about groundwater than about any other water source. This is because each groundwater basin is unique and production characteristics of wells are often interlinked. Since groundwater use is largely unregulated, the actual quantity of energy used for groundwater pumping statewide is also not readily determinable.[18]

In a 2003 study, the Electric Power Research Institute (EPRI) estimated national averages ranging from 700 to 1,800 kWh/MG, depending on use and customer sector.[19] Dr. Robert Wilkinson, director of Water Policy Program at the Bren School of Environmental Science and Management, University of California, Santa Barbara, estimated 2,915 kWh/MG, for groundwater pumping in the Chino Basin.[20] This number reflects the fact that the groundwater aquifers in Southern California, where the Chino Basin is located, are relatively deep compared to those in the northern and central part of the state.

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[16] ACWA Water Facts website.
[17] USGS 2005, Introduction to Aquifer Storage and Recovery, [http://ca.water.usgs.gov/issues/6.html].
[18] Hundreds of thousands of groundwater wells are privately owned, and serve residences, farms, businesses, and small water systems. The electricity used for pumping from private wells is often not separately metered and is not captured in the Energy Commission's and electric utilities' energy use data.
[19] "Water & Sustainability (Volume 4): U.S. Electricity Consumption for Water Supply & Treatment – The Next Half Century", EPRI Topical Report, March 2002.
[20] Dr. Robert Wilkinson's presentation to the January 14, 2005 *Energy Report* Committee workshop.

It is reasonable to expect wide variability in the energy intensity of different groundwater sources, depending upon both the depth at which the groundwater resides and the efficiency of the pumps and motors used to pump it. In the context of energy intensity and benefits to the state, the primary benefit of groundwater is its ability to offset the high energy intensity of SWP deliveries in the fall. In Southern California, some water agencies already pump groundwater during the summer and recharge aquifers with SWP imports during the non-summer months. Even at the upper end of energy intensity, using local groundwater supplies to defer summer deliveries of SWP water to Southern California results in significant energy and reliability impacts for the state overall.

Ocean and Brackish Water

Treating ocean or brackish water -- desalination -- began in California in 1965. In 1999, there were 30 desalting plants operating in California for municipal purposes, with total capacity of 80,000 acre-feet per year. Table 2-1 illustrates the expected growth in desalination in California.[21] If all of the planned new capacity is built, total production of desalination will increase from about 80,000 acre-feet per year to nearly 600,000 acre-feet.

Table 2-1: Desalting in California for New Water Supply

	Plants in Operation		Plants in Design & Construction		Plants Planned or Projected	
Feedwater Source	No. Of Plants	Annual Capacity	No. Of Plants	Annual Capacity	No. Of Plants	Annual Capacity
Groundwater	16	79,100	6	29,500	6	61,700
Seawater	7	1,500	1	300	13	415,100
Total	23	80,600	7	29,800	19	476,800
Cumulative			30	110,400	49	587,200

1. Capacity in Acre-feet per year. No. of Plants is the number of new plants.
2. Design & Construction – Construction underway or preparation of plans and specifications has begun for new plants or plant expansions.
3. Planned – Planning studies underway for new plants or plant expansions.
4. Projected – Projected new plants or plant expansions.
5. Sources: "Water Desalination Report" and Worldwide Desalting Plants Inventory series by International Desalination Association as cited in the DWR Bulleting 160-05.

Source: 2005 State Water Plan Update, DWR

[21] *California Water Plan Update 2005* Volume 2, Resource Management Strategies, Chapter 6 Desalination.

Recycled Water

The fastest growing new source of water in the state is not a new source at all; it's recycled water from wastewater systems, commonly referred to as reclaimed water or reuse. Californians have used recycled water since the late 1800s. Faced with increasingly stringent requirements governing disposal of wastewater and limited water supplies, many agencies are installing additional treatment facilities that can purify wastewater to the point where it can be substituted for fresh water in many applications, including power plant cooling and landscape irrigation.

The primary benefit of increasing the use of recycled water, from an energy perspective, is the displacement of other, more energy-intensive water supplies.

- By using local recycled water to recharge depleted groundwater aquifers in Southern California, the amounts of energy-intensive seawater desalination and SWP imports could be reduced.

- When recycled water is distributed to local end users for landscape irrigation, significant energy savings accrue:

  - First, from displacing the energy intensity of the highest marginal water source.

  - Second, from avoiding the energy used to treat the water unnecessarily to potable water standards.

Since recycled water is often a by-product of existing secondary and tertiary wastewater treatment processes, it is the least energy-intensive source in the state's water supply. While incremental energy is typically required to pump recycled water uphill to redistribute it to end users, this incremental energy is offset in part or in whole by displacing higher energy intensity water supplies, as well as reducing potable water treatment and distribution.

The actual net energy benefit of any proposed project also needs to consider the incremental energy that might be needed to treat the wastewater to higher standards than normal, such as targeted end use water quality requirements. Table 2-2 describes the level of treatment needed for different types of reuse.

Table 2-2: Demand Sectors and Minimum Treatment Levels

Demand Sectors and Examples of Minimum Treatment Levels for Specific Uses to Protect Public Health

Types of Use	*Treatment Level*		
	Disinfected Tertiary	*Disinfected Secondary*	*Undisinfected Secondary*
Urban Uses and Landscape Irrigation			
Fire protection	☑		
Toilet & urinal flushing	☑		
Irrigation of parks, schoolyards, residential landscaping	☑		
Irrigation of cemeteries, highway landscaping		☑	
Irrigation of nurseries		☑	
Landscape impoundment	☑	☑*	
Agricultural Irrigation			
Pasture for milk animals		☑	
Fodder and fiber crops			☑
Orchards (no contact between fruit and recycled water)			☑
Vineyards (no contact between fruit and recycled water)			☑
Non-food bearing trees			☑
Food crops eaten after processing		☑	
Food crops eaten raw	☑		
Commercial/Industrial			
Cooling & air conditioning - w/cooling towers	☑	☑*	
Structural fire fighting	☑		
Commercial car washes	☑		
Commercial laundries	☑		
Artificial snow making	☑		
Soil compaction, concrete mixing		☑	
Environmental and Other Uses			
Recreational ponds with body contact (swimming)	☑		
Wildlife habitat/wetland		☑	
Aquaculture	☑	☑*	
Groundwater Recharge			
Seawater intrusion barrier	☑*		
Replenishment of potable aquifers	☑*		

**Restrictions may apply*

Source: DWR's Water Facts 23 issued October 2004.

In most circumstances, from an energy perspective, recycled water made as a by-product of the wastewater treatment process is the most preferred option. Primary barriers to increasing the use of recycled water include the incremental cost of dual piping systems to deliver this source of non-potable but usable water and public apprehension about using water recovered from the sewage treatment process.

The Energy Intensity of the Water Resource Portfolio

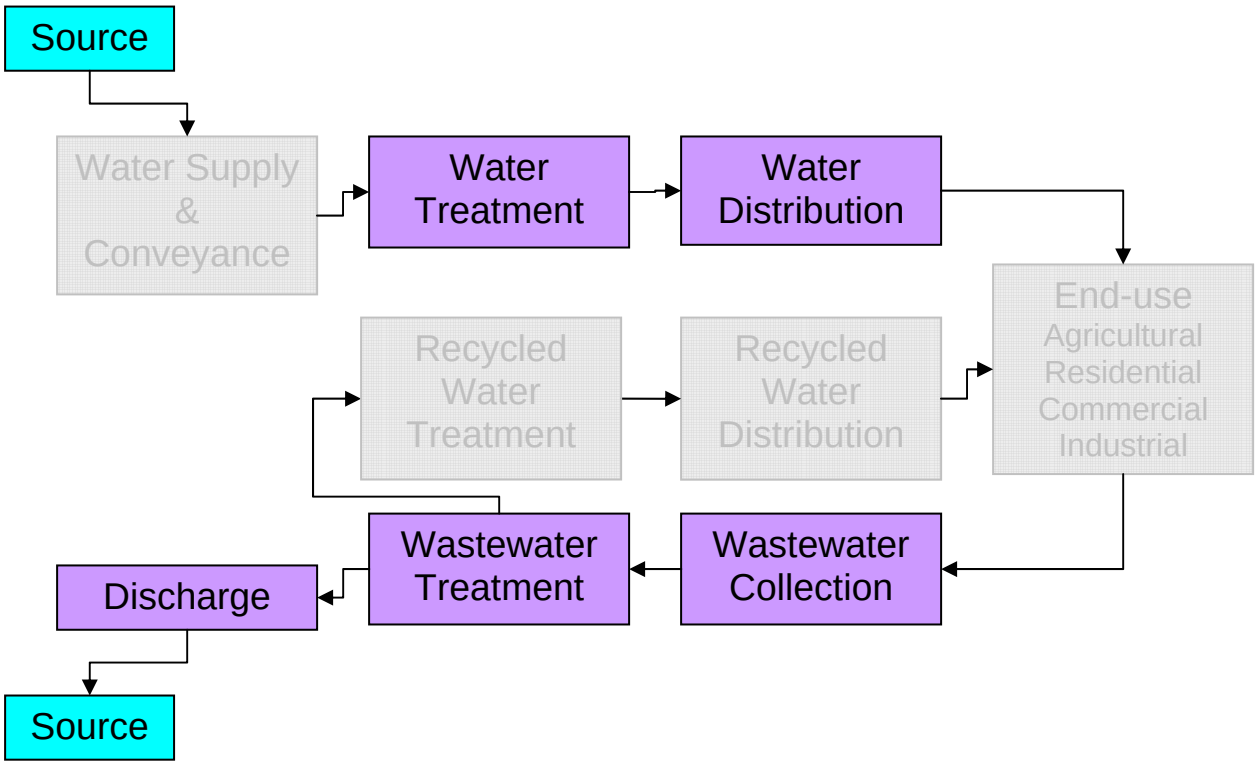
Ultimately, all of these resource choices come together in a water utility's water resource portfolio. Similar to energy utilities, water utilities conduct integrated resource planning (IRP) on a "least cost/best fit" basis. Since energy is typically the highest cost of water supply resources, embedded energy in delivered water supplies is generally reflected in the preferred loading order of water resources in the state's *2005 Water Plan Update.* Using water more efficiently frees up current resources to meet some of the future demand growth.

This is particularly critical in Southern California, where its water mix is roughly half from local sources, and half from imported sources. While water utilities are working hard to develop more local supplies and improve water use efficiency, there are not many options to develop new water sources. Presently, the primary available options are recycled water and seawater desalination.

CHAPTER 3 – WATER AND WASTEWATER TREATMENT AND DISTRIBUTION

This section will discuss, due to their similarities, both the energy intensity of potable and waste water treatment and distribution and the distribution of recycled water.

Figure 3-1: Water Use Cycle – Treatment and Distribution



Energy use for water distribution loads is primarily for pumping water and maintaining sufficient pipe pressure to assure that flows can be made at scheduled rates while maintaining sufficient pressure for fire service.

Water and wastewater treatment processes also use large quantities of energy. In water treatment, energy requirements depend primarily on the characteristics of the raw water, plant size, treatment process, and the distance and elevation of the treatment plant in relation to water sources and water distribution systems. In wastewater treatment, the characteristics of the influent and the level of treatment (primary, secondary or tertiary) are principal drivers of energy consumption.

Electric loads at water and wastewater treatment plants consist primarily of pump motors but also include air blowers, injection equipment, controls, lighting, and, in

some cases, ultraviolet light disinfection and ozonation. Wastewater treatment plants also require activated sludge and sludge handling systems that consume large quantities of energy. The Energy Commission Demand Office estimates that a total of about 9,000 GWh of electricity is used annually by both water and wastewater facilities. This is based on both electric and water meter data and assumptions from engineering handbooks and other sources about the electricity use of certain equipment. Because the meter data is not reported in separate categories it cannot be disaggregated to separate water from wastewater treatment.

The Association of California Water Agencies (ACWA) estimates that the state's water and wastewater treatment facilities collectively draw about 3,000 MW at peak, with 1,800 MW occurring in Southern California Edison's (SCE) service territory, with the rest geographically distributed throughout the state more or less in proportion with population.

Both water and wastewater treatment processes require pumps and motors to transport water before, during, and after treatment. Pumping is not as significant a portion of the load for wastewater as for water because wastewater treatment processes are significantly more energy intensive, and both wastewater collection and disposal typically rely heavily upon gravity. Thereafter, the treatment processes and their relative energy intensities vary considerably.

Water treatment has historically been a comparatively modest user of energy, relying primarily upon settlement and passive filtration to remove particles from water, and chemical treatment (chlorination or chloramination) for disinfection. As new water quality regulations are implemented, energy-intensive technologies such as membranes, UV and ozonation will require large quantities of energy. Wastewater treatment requires much more energy, with each progressive level of treatment requiring still more. In secondary treatment, most of the energy is used for biological treatment; pumping of wastewater, liquid sludge, biosolids and process water; and processing, dewatering, and drying of solids and biosolids. Tertiary treatment requires additional energy for aeration, pumping, and solids processing. All of these processes present opportunities for energy reduction.

To reduce energy costs, many utilities have already replaced pumps and motors with newer, more efficient equipment. The addition of variable frequency drives and customized pumping algorithms provide the capability to further reduce energy requirements by more closely matching pumping capacity with loads. In addition, both water and wastewater utilities have recently demonstrated that significant reductions in energy consumption could be achieved by employing interim storage to shift processing to off-peak periods and balance processing loads among multiple plants to optimize plant efficiencies.

In the mid-1990s, EPRI and HDR Engineering, Inc. conducted an audit of the energy savings potential for water and wastewater facilities in California. At that time, they estimated that more than 880 million kWhs could be saved by implementing several measures: load shifting, variable frequency drives, high-efficiency motors and

pumps, equipment modifications, and process optimization with and without Supervisory Control and Data Acquisition (SCADA) systems. These estimates did not include incorporating interim storage to shift loads and optimize plant efficiencies. Industry experts estimate that untapped energy efficiency opportunities through the optimization of water and wastewater treatment processes could be as high as 30 percent of existing processes.

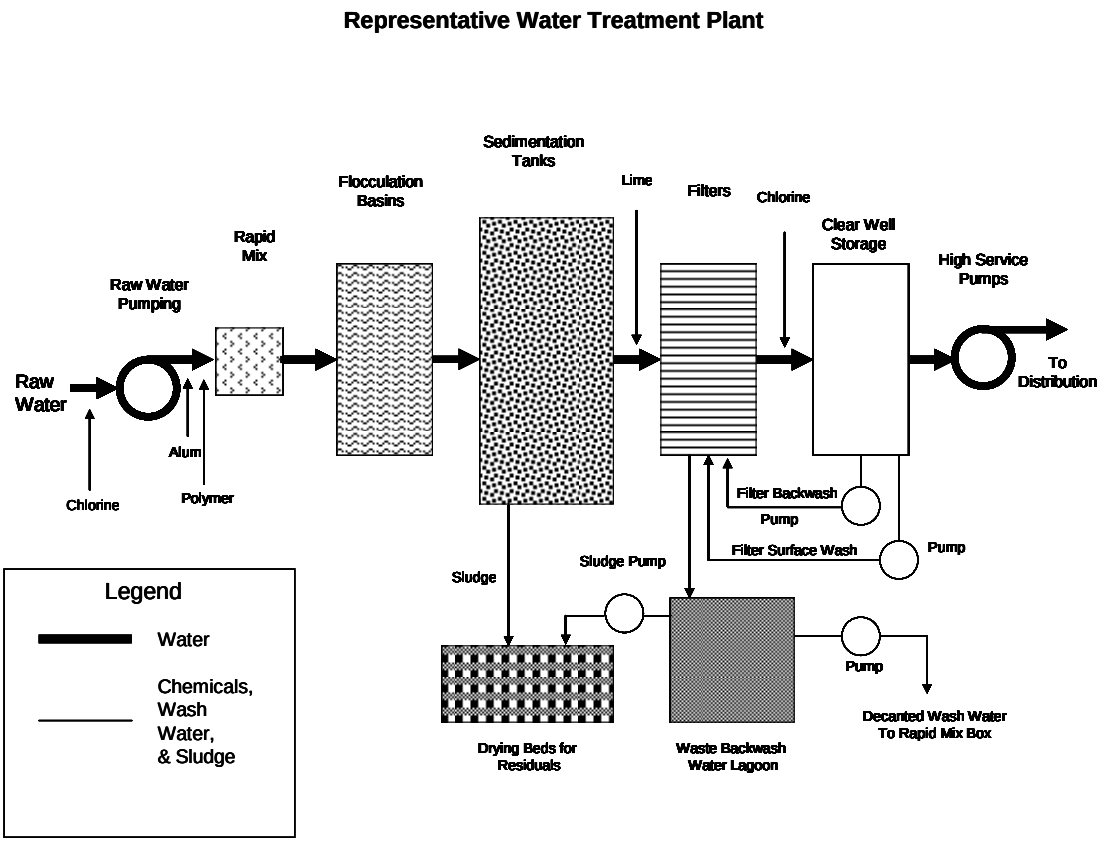
The sections below will describe energy uses for water treatment and distribution, and for wastewater treatment.

Water Treatment

Source water quality and the end use of the water dictate the level of treatment required. For potable uses, a typical sequence of operations for surface water treatment is described in the following steps (refer to Figure 3-2).

- Raw water is first screened, pre-oxidized using chlorine or ozone to kill organisms.
- Alum and/or polymeric materials are added to the water.
- Flocculation and sedimentation remove finer particles.
- A second disinfection step kills remaining organisms.
- The clear tank allows contact time for disinfection.
- Treated water is distributed to consumers by high-pressure pumps (disinfectant residue is carried into the distribution system to prevent organism growth). Sludges and other impurities removed from water are concentrated and disposed of.

Figure 3-2: Sequence of Operations in Surface Water Treatment



Source: Electric Power Research Institute

As shown in Table 3-1, although no two treatment facilities are identical, the following survey of more than 30,000 public supply systems in the United States[22] indicates little variation in water treatment energy intensity for plant capacities of at least 1 million gallons per day[23].

[22] Inventory of public water supply systems maintained by the U.S. Environmental Protection Agency in the Safe Drinking Water Information System.
[23] *Water & Sustainability* (Volume 4): *U.S. Electricity Consumption for Water Supply & Treatment*, EPRI March 2002, Figure 2-1, page 2-2,

Table 3-1 Energy Use by Surface Water Treatment Plants

Plant Size (Million Gallons per Day)	Energy Intensity (kWh/MG)
1	1,483
5	1,418
10	1,406
20	1,409
50	1,408
100	1,407
Average	**1,422**

Source: Electric Power Research Institute

Water treatment energy requirements are driven principally by the characteristics of incoming raw water and by the distance and elevation of the treatment plant in relation to water sources and the distribution system. Actual energy demand is highly variable by water utility. Lowest is pristine Hetch Hetchy water, which is exempted from filtration by the U.S. Environmental Protection Agency (US EPA)[24]. However, most surface and groundwater sources require treatment to meet regulatory standards and the taste and odor preferences of the public. Some treatment plants also have unique requirements, such as the removal of industrial chemicals from well water that require more energy. Net energy demand is expected to change as more energy-intensive disinfection processes are used to address water quality concerns and meet increasingly stringent potable water rules under the federal Safe Drinking Water Act (see discussion in Chapter 6).

Despite extensive data searches, staff found only a few studies that attempted to determine the exact electricity use for water treatment facilities. One of the most comprehensive and innovative studies came from an effort in Sonoma County to address greenhouse gas emissions. This study included energy use by municipal facilities, including the county's wholesale water agency, the Sonoma County Water Agency, and all of its municipal system water customers.

The Sonoma County Water Agency provides domestic water to 540,000 domestic water users in Sonoma, Marin, and Mendocino counties. Its only source of water is the highly variable flow of the Russian River and storage in two reservoirs on tributaries of the Russian, Lake Sonoma, near Healdsburg, and Lake Mendocino, near Ukiah. The EPA has listed the Russian River as impaired because of dissolved solids and nutrients. To both avoid these impairment issues and comply with federal

[24] The high quality Hetch Hetchy's water supply, produced by Sierra snowmelt in a protected watershed, has been granted a filtration exemption from the U.S. Environmental Protection Agency (U.S. EPA) and the California Department of Health Services (DHS).

Endangered Species Act limitations on stream withdrawals, many of the county water agency's municipal customers mix the river water with about equal amounts of groundwater, which is generally less costly.

The Sonoma County Water Agency required nearly 2,600 kWh/million gallons to pump and treat water from the river over the period of April 2000 to September 2002. Pumping costs were essentially linear throughout the year (that is, the electricity use per million gallon rate was essentially constant) except for spikes in January and February, when large amounts of surplus water were transferred to storage in reservoirs, especially in Marin County (Rosenblum 2003). Data are insufficient to determine the amount of energy used for pumping the water (which corresponds to the "Collection, Extraction and Conveyance" portion of the water use cycle described in Chapter 2) as opposed to energy used solely for water treatment.

In addition to Hetch Hetchy, EBMUD is an example of an agency with energy intensity of water treatment on the lower end of the spectrum. EBMUD gets 95 percent of its water from the Mokelumne River, delivered by gravity through the Mokelumne Aqueduct. The Mokelumne water is relatively high quality at its source, requiring little treatment; and the EBMUD's treatment facilities are located high in the East Bay Hills, using elevation to help pressurize its distribution system. Because of these factors, EBMUD's electricity use is a low 150 kWh/million gallons for conveyance, and 275 kWh/million gallons for treatment (EBMUD 2000 and Navigant Consulting 2004).

Desalination

Desalination involves removal of salts and dissolved solids from seawater or brackish water. Most desalination processes are based on either thermal distillation or membrane filtration technologies, both of which are very energy intensive.

The primary benefit of desalination is its ability to increase potable water supply by reclaiming water of poor quality. The most significant challenge of desalination is that it is a very energy-intensive source of water, and its highest use will likely coincide with extended drought periods when hydropower production is lowest.

Unlike every other type of water facility, where staffing edges out energy use as the main expense, desalination's primary operating cost is for energy, with seawater desalination being considerably more energy intensive (9,780-16,500 kWh/million gallons) than brackish groundwater desalination (3,900–9,750 kWh/million gallons).[25] The difference between seawater and brackish desalination ranges is due primarily to the difference in the initial water quality, and within each range the variance is due primarily to the plant design and technology employed. Most desalination plants operate continuously, so this electricity is used during all seasons and at all times of

[25] California Department of Water Resources Desalination Task Force Final Report 2003.

the day. Current plants are operating 90 percent of the time, with downtimes only for maintenance (DWR, 2005).

According to the *2005 Water Plan Update*, a 50 MGD seawater plant (approximately 50,000 acre-feet per year, or 16.25 billion gallons, assuming operations 90 percent of the time) would require about 33 MW of power.[26] This translates to about 5,200 kWh per acre-foot, or 16,000 kWh per million gallons, which is the upper-end of California's energy intensity of water supplies. Multiple efforts are underway to increase the energy efficiency of desalination through improved membranes, dual pass processes, and additional energy recovery systems.

Present estimates indicate that existing desalination facilities use 370-890 GWh per year. As stated in Chapter 2, if all of the planned new capacity is built, total production of desalination will increase from about 70,000 acre-feet per year to nearly 300,000 acre-feet. Assuming an average of 3,900 kWh/acre-foot (about 12,000 kWh per million gallons),[27] an incremental 230,000 acre-feet would require about 897 GWh. In the IEUA example, desalination of local brackish groundwater supplies can produce a net energy benefit when displacing higher energy intensity desalted seawater or SWP imports.

Desalination of seawater has the highest energy intensity of all water treatment options.

Water Distribution

Once treated to potable standards, the water must be distributed to customers, generally through a network of storage tanks, pipes, and pumps. During distribution, water must be kept moving and under pressure to minimize corrosion and biological contamination. Storage tanks and water mainlines must be flushed periodically to prevent oxidation and control biofilms (AWAARF 2000). Even the farthest reaches of the network must be kept under adequate pressure and constantly flushed since low pressure and low flow allow microbes to flourish (ACWA workshop April 14, 2005).

On average, staff estimates that city water agencies use about 1,150 kWh/million gallons of electricity just to deliver water from the treatment plant to their customers. The energy required for distribution pumping is mainly driven by the distribution system configuration, its relative size, elevations, and system age.

The water supply diagram and the results of the EPRI survey in Table 3.1, above, reflect little variation in the amount of energy required to treat and distribute a unit of water for systems requiring at least 1 million gallons per day. For this large survey

[26] *California Water Plan Update 2005* Volume 2, Resource Management Strategies, Chapter 6 – Desalination.
[27] The average of the Chino desalter and seawater desalination in IEUA's water supply options.

size of approximately 30,000 public water supply systems, distribution pumping of treated water remained fairly constant at between 80 to 85 percent of total energy requirements when treatment and distribution energy loads are combined. For purposes of this paper, staff adopted this ratio and assumed prototypical water distribution energy intensity to be about 1,200 kWh/MG.

Cities with hilly terrains can use hilltop tanks both as storage and to provide pressure into the distribution system; San Francisco is perhaps the best example of this, serving virtually all of its customers from hilltop tanks. But the water must first be pumped up to the tank, often several hundred feet in elevation. In addition, though water agencies loathe wasting water and energy, they often must flush water from the tanks to prevent microbial contamination and then fill them up once again through the pumping station. In fact, this flushing accounts for the bulk of electricity used in EBMUD's distribution system.

Wastewater Treatment

Other than water devoted to landscape irrigation, or lost through evaporation (such as in cooling towers and other processes), almost all the water entering homes and businesses in California eventually leaves as wastewater. Wastewater treatment is similar to freshwater treatment. But most wastewater treatment systems have the additional step of using biological reactors that use bacteria to break down waste. Wastewater pumps are inherently more inefficient because they must pump both liquids and solids, and must have greater clearances between the pump impeller and the casing, allowing much of the pumped water to return to the intake plenum. Energy use in a wastewater system is primarily from use of very large electric pumps and blowers and use of natural gas to heat the anaerobic digesters.

Digester biogas (approximately 60 percent methane and 40 percent CO_2) is produced by anaerobic bacteria. The gas can be collected and used to generate electricity, usually powered by an internal combustion engine and used to run the facility itself. Waste heat recovered from the engine can be used to heat the digesters and displace natural gas use.

The number of water and wastewater treatment techniques and the combinations of techniques are expected to increase over time as more complex contaminants are discovered and regulated.

Wastewater consumes electricity in three stages: transport to the facility, treatment, and disposal/recycle. The first stage, transporting from the customer to the wastewater treatment facility, requires about 150 kWh/million gallons of electricity on average to pump the water, depending on topography, system size, and age. When they have a choice, agencies prefer to place water treatment facilities above their customers and the wastewater treatment facilities below, to harness the pull of

gravity where possible, and to place water intakes above wastewater outfalls on rivers.

There are levels of treatment, and each progressively requires higher levels of energy use. These steps may consist of physical processes, biological processes, or chemical processes.

Physical Processes
The initial steps involved in the sewage wastewater treatment are physical processes, which separate larger solids from liquid using screening or grit removal. Steps that remove larger solids are termed preliminary treatment. The solids separated from the preliminary processes are usually disposed of in a landfill. After removal of larger solids, primary treatment follows to separate the smaller solids. Some chemicals may be added to assist with solids removal.

Biological Processes
The physical processes are followed by biological aerobic treatment in which extended aeration (oxygen) and environmental conditions are provided for microbes to break down organic material into carbon dioxide and water. Equipment used for the aerobic treatment includes tricking filter, aeration basin, and others. This biological aerobic treatment is commonly called secondary treatment.

After the aerobic treatment, the wastewater is separated with a sedimentation tank to separate the sludge and the clear effluent. The sludge is then sent to an anaerobic digester where the organic material is broken down into biogas, which is primarily methane and carbon dioxide.

Chemical Processes
The clear effluent, after the secondary treatment is further treated with physical filtration, chemical, or ultraviolet disinfections. This further treatment is commonly called tertiary treatment. The tertiary effluent can be used for beneficial reuse or discharged to surface water.

The progressive levels of treatment are commonly referred to as “primary”, “secondary” and “tertiary”, with primary being the lowest level, and tertiary the highest. Effluent from both secondary and tertiary treated water can be reused. The levels of treatment required for types of reuse (i.e., recycled water) are described in Table 2-2 in Chapter 2.

The major driver of unit energy consumption is the degree of treatment required. As noted above, there has been a trend toward more thorough treatment, with upgrades or replacements of older systems that could not provide this higher level of treatment. This trend is seen in comparing the estimated unit electricity consumption in 1988 with consumption in 2000: the baseline unit energy consumption was

estimated to increase at an average compound rate of about .08 percent per year. This upward trend in unit electricity consumption is expected to continue as more thorough treatment is required.

Unlike water treatment and distribution systems, unit volume energy requirements for wastewater treatment plants vary greatly depending upon plant size. Energy intensity for a 1 MGD wastewater treatment plant can be approximately three times that of a 100 MGD wastewater treatment plant[28]. As expected, unit electricity consumption rises as the degree of treatment and complexity of the process increases. For example, advanced wastewater treatment with nitrification is three times as energy intensive (due to additional pumping requirements) than that of a relatively simple trickling filter plant.[29] Further complicating the assessment of prototypical unit volume energy intensity are unique operational environments, discharge limitations, influent characteristics, permitted effluent limitations, and variations in plant permitting cycles.

Table 3-2 Energy Intensity of Wastewater Treatment Facilities

Source of Data	kWh/MG
Inland Empire Utilities Agency	2,971
City of Santa Rosa	2,920
East Bay Municipal Utilities District	2,001
Metropolitan Water District	2,655
Methodology for Analysis of Energy Intensity in California's Water Systems	1,911
Energy Down The Drain, The Hidden Costs of California's Water Supply	2,302
Energy Benchmarking Secondary Wastewater Treatment	2,625

Source: Multiple, see Appendix C

Table 3-2 shows wastewater treatment plant energy intensities reflecting a range of energy intensity for facilities operating in California and cited in studies. Based on this range, 2,500 kWh/ MG has been adopted as the prototypical wastewater treatment energy intensity (for more detailed discussion and references see Appendix C).

One of the most interesting opportunities for reducing energy use for wastewater treatment is to improve storm water management. During rainy weather, a considerable amount of runoff ends up in wastewater systems, greatly increasing treatment costs. Even communities that do their best to keep stormwater out of their sewer systems see nearly double the flow during a winter storm than during the dry summer months. This “infiltration/inflow” of stormwater into the sewer system has on

[28] *Water & Sustainability* (Volume 4) *U.S. Electricity Consumption for Water Supply & Treatment – The Next Half Century*, EPRI 2002, Pages 3-4 & 5 and Table 3-1.
[29] *Water & Sustainability* (Volume 4) *U.S. Electricity Consumption for Water Supply & Treatment – The Next Half Century*, EPRI 2002, Pages 3-4 & 5 and Table 3-1.

occasion forced many communities to discharge raw or minimally treated wastewater directly into local waters.

For example, Sonoma County's largest wastewater facility, the Laguna Wastewater Treatment Plant, operated by the City of Santa Rosa, experienced a peak inflow of nearly a billion gallons per month in January and February of 2000 and 2002, while average inflow in the summer months was just over half that amount (Rosenblum 2003, Figure 7). Its wastewater treatment electricity use is proportionate to these flows, and therefore nearly twice as high in winter than in summer.

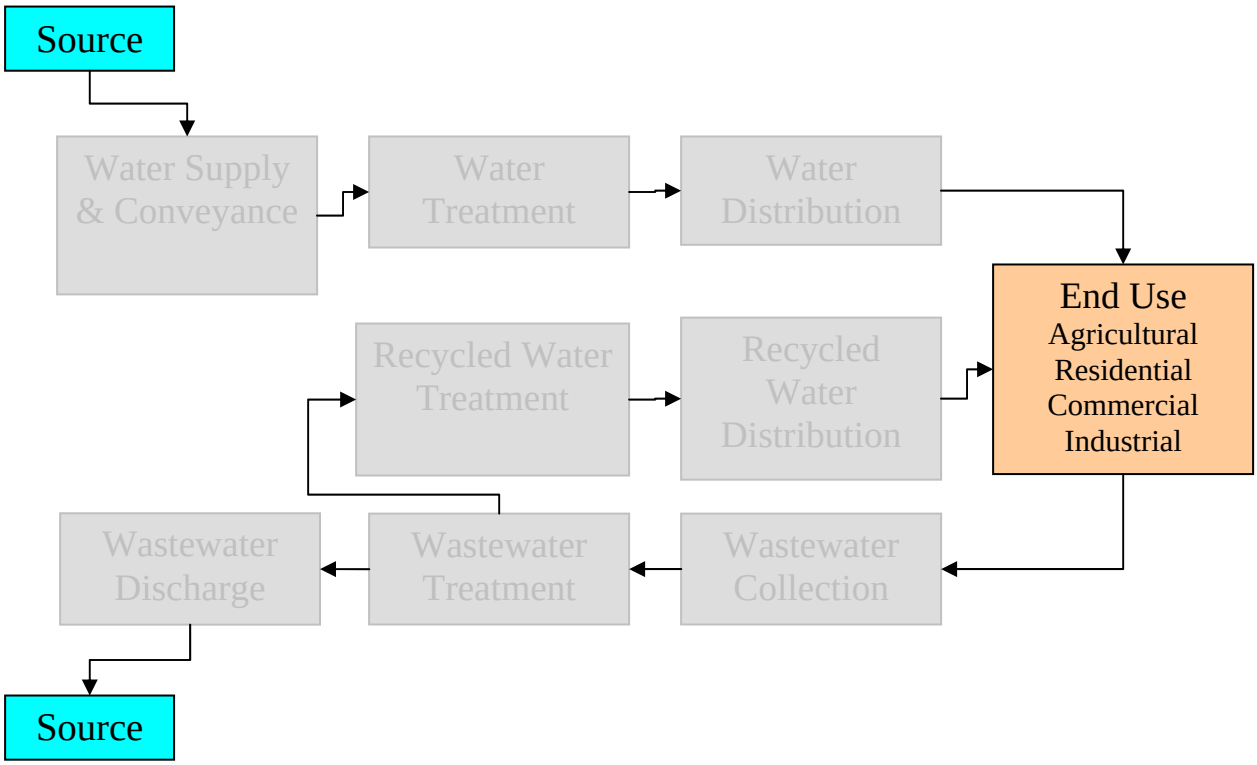
Conclusions

In this chapter, staff has generally described water energy intensity for water treatment, wastewater treatment, and water distribution. Staff has also identified areas that will require additional information and analysis to better understand these systems and how modifications or improvements could benefit the energy sector. Future regulatory changes made in response to health and water quality concerns will affect the overall energy demand of these systems.

CHAPTER 4 – WATER RELATED END-USE EFFICIENCY

This chapter addresses opportunities to increase water and energy end-use efficiency.

Figure 4-1: Water Use Cycle – End Use



The Energy Impact of Water Use Efficiency

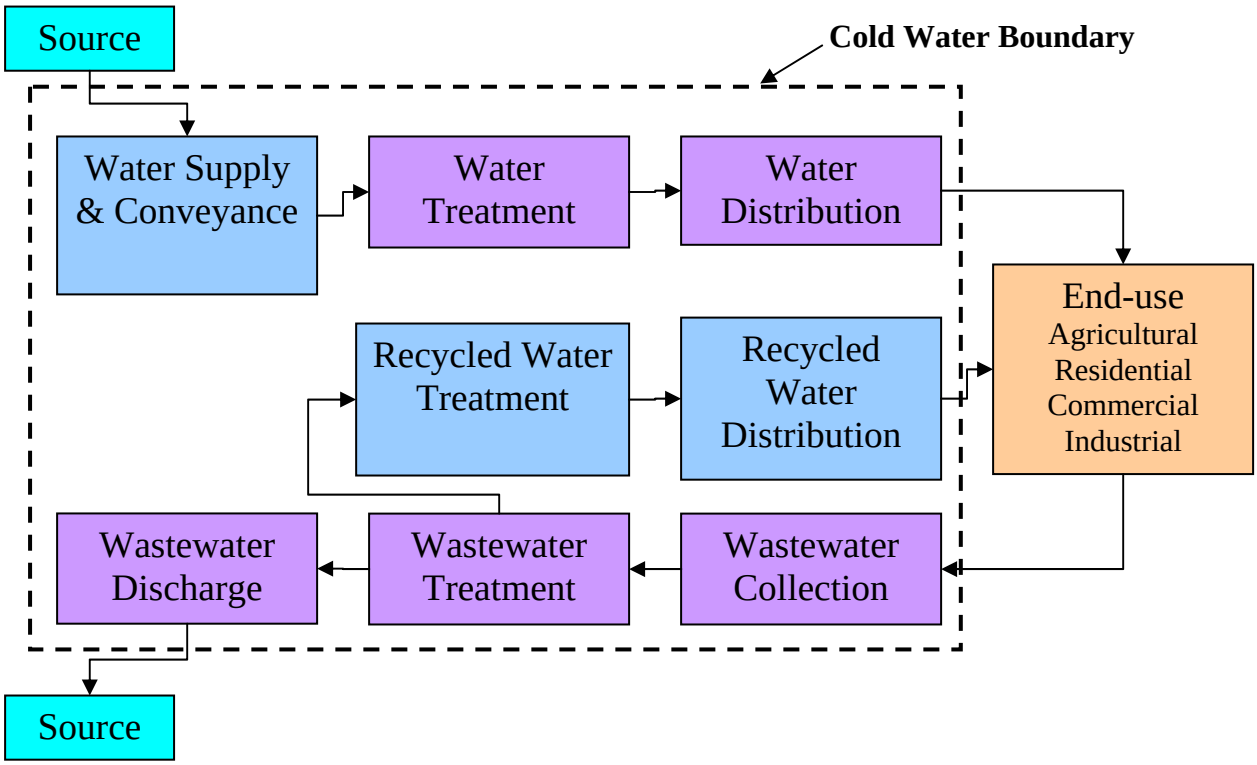
Water end-use applications in California use more energy than any other part of the state's water use cycle. Energy efficiency water programs have traditionally focused on either saving energy in water and wastewater treatment facilities or saving energy in end-use applications including water heating, clothes washing and drying or process heating. Water use efficiency programs have similarly focused on saving water in end-use applications. In both cases, end-use efficiency measures are beneficial, to both utilities and end users, when the value of the saved energy or water exceeds the cost of the measure.

For the most part, these efficiency improvements have been pursued separately by water and energy utilities, although there are some examples of close coordination, including the effort to introduce high-energy-efficiency and low-water-factor clothes washers to the consumer market. What appears to be missing is the recognition that saving water also saves energy throughout the conveyance, treatment, distribution and wastewater treatment processes of the water use cycle.

The energy intensity of water use varies depending on its end use and location in the state. For example “statewide average,” agricultural end uses are less energy-intensive than either “statewide average” urban end uses or agricultural end uses in Southern California that rely upon SWP or Colorado River Aqueduct water deliveries. All are more energy-intensive than those in Northern California. On average, urban water uses in Southern California are more than three times as energy-intensive as those in Northern California.

While these relationships are useful for policy development and planning, it is important to recognize that the actual energy intensity of the water use cycle is very location- and application-dependent; this information is important as specific projects are considered. Figure 4-2 shows the overall cold water boundary. To apply the concept of energy intensity, the cold water boundary must be identified for specific locations and applications. Further details are in Appendix C.

Figure 4-2 Cold Water Boundary in the Water Use Cycle



Conserving a unit of cold water avoids using the energy that would have been needed to supply, treat, deliver, consume, collect, treat, and dispose of it as wastewater. The actual amount of energy saved depends upon the type and source of water supply, the distance the water has to travel, the nature and extent of its treatment, and the type of end use.

In California, saving cold water, both indoors and outdoors, saves energy. The energy saved is primarily electricity. Saving outdoor water saves the energy it takes to extract, convey, treat, and distribute water to customers. Saving indoor water saves the additional energy, again mostly electricity, used to collect, treat and dispose of the waste water. Saving indoor hot water saves the additional energy needed to heat this water. In California, this additional energy is mostly in the form of natural gas.

From an energy perspective, saving cold outdoor water is good. Saving cold indoor water is better. Saving hot indoor water is better still.

Saving end-use energy can also save water and the energy associated with the applicable portion of the water use cycle. For example, when air conditioning is reduced in large buildings that use cooling towers to remove the heat, every unit of energy that does not need to be removed means that less water is needed in the process. Also, saving electricity in any fashion saves water at power plants that use cooling water.

Agricultural Water Use Efficiency

About 79 percent of the state's water is used by the agricultural industry to grow more than 200 crops that generate more than $29 billion dollars a year for the state's economy (CDFA, 2003). Because water conveyance and pumping are very costly, efficient irrigation technologies and farming practices hold promise for reducing both the amount of water needed and the energy intensity of crop production.

While a unit of agricultural water is not as energy intensive as a unit of urban water, the agricultural industry strives to meet water conservation objectives, save money, and preserve water resources. Many times the adoption of natural resource conservation practices creates new energy expenditures. The industry can reduce these costs by participating in energy efficiency and demand response programs through the public goods charge funds administered by their investor-owned utilities (IOU).

Energy Efficiency and Conservation Measures

Since the mid-1990s, the agricultural industry has adopted multiple water conservation practices, among which are installation of drip- and micro-irrigation

technologies. The use of on-farm pressurized irrigation methods has increased from about 1.4 million acres in the early 1980s to more than 4.2 million acres today.[30] These changes can result in better crops, reduced water use, and the reduced use of fertilizers and chemicals, all of which result in greater productivity and energy efficiency.[31]

To be more productive, farms must also improve the efficiency of their water pumping systems. Since the 2000-2001 energy crisis, thousands of farmers and irrigation districts have used state- and ratepayer-funded pump test and repair program incentives. Many of the pumps were repaired to boost their pumping plant efficiencies.[32] When pump tests are performed and cost-effective pump repairs are completed, pump efficiencies can increase by 5 to 15 percentage points. This improved efficiency provides increased pumping capacity. Where previously a farmer might have used seven days to water his fields, it might now instead take five or six days to do the same work. Most farmers will adjust their irrigation set times to reflect the new water output and reduce the total number of hours of operation, saving both water and energy.

These measures can more than offset the new energy requirements that most often accompany drip system installations. Although there will be a higher demand for connected load from the installation of booster pumps, the total hours of operation will depend on the source of water and the irrigation system that is being converted to drip. Most often farms are required to pump from groundwater sources to satisfy the on-demand, clean, and flexible water delivery needs of the drip systems, possibly increasing their energy costs. Studies have shown that the conversion from surface irrigation to drip/micro- and sprinkler-irrigation technologies has lead to increased on-farm groundwater pumping on the east side of the San Joaquin Valley.[33]

Adoption of Time of Use (TOU) Agricultural Electric Rates

Large numbers of both Pacific Gas and Electric (PG&E) and SCE agricultural customers have signed on to TOU electric rate schedules. In the PG&E service area 81 percent of agricultural revenues and 89 percent of agricultural kWh sales are on TOU rates, representing 40,000 accounts of the total 80,000 agricultural accounts[34]. In the SCE service area, 71 percent of agricultural kWh sales are on TOU rates, generated by 18 percent of the utility's customer accounts[35].

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[30] CalPoly ITRC, Memorandum, 2005
[31] CalPoly San Luis Obispo University, ITRC Report No. R 96-001, Row Crop Drip Irrigation on Peppers Study - High Rise Farms, 2006
[32] Nexant, M&V report from the California Energy Commission Agricultural Peak Load Reduction Program, 2003
[33] CalPoly ITRC, California Agricultural Water Electrical Energy Requirements, 2003
[34] Personal communication with Keith Coyne, PGE, 8 4 2005
[35] Personal communication with Cyrus Sorooshian, SCE, 8 11 2005

Although there are many accounts on TOU rates, farmers still use energy during peak-period hours. If crop water needs require irrigating during peak periods, the farmer will exercise the option to use on-peak power and pay the penalties, leading to higher average energy costs. The farmer's goal is to provide water to crops when it's needed, in the proper amount, using high distribution uniformity for optimal crop growth. It is not always possible to meet all of these requirements and take maximum advantage of TOU rates.

Staff recognizes that, to pump water during off-peak hours, farms will require larger pumping plants with properly designed irrigation systems, improved control systems, and flexible working hours. To take full advantage of these changes farmers will have to maintain high efficiencies in their pumping and irrigation systems in addition to adopting scientific irrigation scheduling management practices.

Agricultural electricity end users would benefit from energy policies that allow end users to choose the demand response practice that best meets the requirements of their business. The industry will also be more inclined to invest in peak load reduction measures with both flexibility and strong stable price signals.

Other Factors Affecting Agricultural Water Energy Use in California

There are several trends to watch that affect the future use of energy to provide water to agriculture, including:

- Sustained adoption of drip and micro irrigation technologies. Although there are more than 4 million acres under drip irrigation, from a total of less than 9 million acres of irrigated land reported for the state, it is reasonable to assume that, over time, another 3 million acres could be converted to drip irrigation. The agriculture industry will make the conversion partly to meet water conservation goals but mostly by recognizing the production benefits from the technology. CalPoly ITRC forecasted an increase of 2.9 million kWh from the doubling of drip irrigation acreage.[36]

- Continued reliance on ground water, with reductions in surface water. There is a high probability that farmers will continue to pump from wells to supply groundwater to drip systems until irrigation districts provide surface supplies with flexible schedules.

- An increase in agricultural water conjunctive use programs with transfers to urban regions. There are many water transfer agreements already in place, with more to come as the urban sector finds that the agricultural industry can provide storage services as well as new water transfers from achieved

[36] CalPoly ITRC, California Agricultural Water Electrical Energy Requirements, 2003.

conservation measures. There are significant energy expenditures to accomplish the process of banking the water, pumping it for extraction and delivering it to the water account owner[37].

- Conversion from diesel-powered pumping systems to electric motors. On August 1, 2005, a new rate schedule (AG-ICE) became available for current agricultural diesel-driven irrigation pumps in both PG&E's and SCE's service territories. The rate encourages the switch from engines to electric motor-driven systems for agricultural customers with diesel engines of greater than 50 horsepower for irrigation pumping before September 1, 2004. In the PG&E territory it is possible that 200 to 300 MW of new coincident peak load could be added to its system during the course of the two-year open enrollment period.[38]

The Energy Commission's *2005 California Energy Demand Forecast* shows that agricultural electricity consumption is expected to increase by 1.4 percent a year through 2016.[39] The actual amount will fluctuate depending upon the total number of irrigated acres, the crop patterns, the source of water and, obviously, the price of electricity.

From a state energy policy perspective, the agricultural industry's effort to achieve electricity use efficiency and demand response savings would satisfy the first target in the state's loading order. The agricultural industry also has the opportunity to adopt the second item in the loading order with installation of renewable energy systems.

The agriculture industry does have great potential to develop renewable energy sources. However, investment recovery will require the aggregation of electricity account meters so that the generated power can be applied to all existing accounts. Today, these accounts can only apply the power produced to the single connection attached to the power system. Therefore only a limited amount of power can be sold at the retail price, with the remainder sold at wholesale prices. This situation is similar to that faced by water and wastewater utilities. These issues affect many customers in the state and are being considered by the CPUC as it attempts to balance a wide variety of factors related to distributed generation in California.

The agricultural industry's economic sustainability greatly depends upon nature's water cycle. During dry years, the amount of energy used to deliver water increases. In drought years, groundwater sources are used extensively to supplement lower surface water deliveries. Several consecutive dry years can also lower the groundwater subsurface level of the water table, requiring more energy to overcome the lift needed to pump the water up to the surface. Typical groundwater lifts vary by

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[37] CalPoly ITRC, California Agricultural Water Electrical Energy Requirements, 2003) [http://itrc.org/reports/energyreq/energyreq.pdf].
[38] Personal communication with Keith Coyne, PG&E August 4, 2005.
[39] *California Energy Demand 2006-2016, June 2005*

region throughout the state, which influence both motor size and power usage. The state has been fortunate in that there has not been a continuous series of dry years since the 1988-1992 drought. Since then, new groundwater recharge basins have been developed to serve as infrastructure for water transfer transactions. These measures are important both for water management flexibility and energy efficiency.

Additional small-scale water storage systems located in irrigation districts and on farms could help increase the flexibility of water deliveries. Surface and tank storage facilities can store water during off-peak periods and reduce the need for on-peak electricity consumption.

Urban Water Use Efficiency

Approximately 21 percent of the state's water is for urban uses. Urban water use efficiency includes improvements in the residential, commercial and industrial sectors. It includes opportunities to increase the efficiency of water-related end uses that use either electricity or natural gas.

In November 2003, the Pacific Institute published a study[40] that estimated the minimum cost effective urban water conservation at around 2 million acre-feet (651 billion gallons) per year, about 22 percent of all urban water use -- without technological change. The California Urban Water Conservation Council (CUWCC) recently posted the results from 32 percent of the agencies that signed on to their memorandum of understanding to institute best management practices (BMPs) in their water agencies. Taking only those BMPs for which water savings could be quantified, the reporting agencies saved more than 27 billion gallons of water in 2004, resulting in significant electricity energy savings, as shown in Table 4-1. The water savings from the BMPs, reported in 2004, are roughly 4 percent of the potential described by the Pacific Institute.

[40] *Waste Not, Want Not: The Potential for Urban Water Conservation in California,* The Pacific Institute, November 2003.

Table 4-1: Energy Value of Saved Water Due to Implementation of 2004 BMP Measures

Statewide	Annual Savings Water (MG)	Annual Savings Electricity (kWh)	Useful Life (Years)	Life-Cycle Electricity Savings (kWh)	NPV Electric Avoided Cost ($)
BMP 1 Water Survey Programs MF/SF	1,897	17,114,500	5	85,572,500	6,220,866
BMP 2 Residential Plumbing Retrofit	311	2,814,000	5	14,070,000	1,022,865
BMP 4 Metering & Commodity Rates	1,587	14,317,200	11	157,489,200	9,472,790
BMP 5 Large Landscape Conservation Programs	5,320	34,595,450	10	345,954,500	21,149,701
BMP 6 High-Efficiency Washing Machine Rebate	317	2,860,100	15	42,901,500	2,346,888
BMP 9 Conservation Programs CII	4,814	43,433,300	12	521,199,600	30,567,522
BMP 9a CII ULFT	258	2,328,300	25	58,207,500	2,522,363
BMP 14 Residential ULFT	12,987	117,184,600	25	2,929,615,000	126,950,010
Statewide Total	27,492	234,647,450		4,155,009,800	200,253,005

Source: California Urban Water Conservation Council (CUWCC) Reporting Database, April 2005 with 86 of 269 Reporting Units (32%) reporting BMP expenditures in 2004. Reporting Units include: water utility districts, water agencies, irrigation districts, city and county water departments and water service companies implementing BMPs.

Saving this water also saved more than 234 million kWh of electricity. Taken over the lifetime of each measure, the net present value of the energy for this saved water is more than $200 million. The saved energy was computed using the urban use energy intensity of 4,000 kWh/MG in Northern California and 12,700 kWh/MG in Southern California. These values assume that all water delivered to these uses is also treated as wastewater and applies to all of the BMPs (except the landscape conservation programs, which used a lower number to account only for the water delivery portion of the water use cycle). The computations were done separately for Northern and Southern California and aggregated to arrive at the statewide totals shown in the table. Details of this analysis can be found in Appendix C.

The energy saved from the saved water was passed on to the California water and wastewater treatment utilities that participated in implementing the BMPs. It also showed up as reduced electricity sales and some peak demand reduction. However, energy savings from savings in the water use cycle were not recognized by either the CPUC or by the energy utilities as fundable energy conservation measures.

Members of the Water-Energy Relationship Working Group presented testimony on this topic, suggesting it would be valuable to assess how large the energy value of the conservation potential identified by the Pacific Institute might be in comparison with energy efficiency programs currently approved by the CPUC. Table 4-2 presents the comparison of programs funded in 2004-2005 with those planned for 2006-2008. The water use efficiency (WUE) program is based on the Pacific Institute's expressed water saving potential.

Table 4-2: Comparison of Energy Efficiency Programs Resource Value to Water Use Efficiency

	Energy Efficiency Programs		
	2004-2005	2006-2008	WUE
GWh (Annualized)	2,745	6,812	6,500
MW	690	1,417	850
Funding ($ million)	$762	$1,500	$826
$/Annual kWh	$0.28	$0.22	$0.13
WUE Relative Cost	46%	58%	

Source: California Public Utilities Commission, with WUE estimates from Appendix C

The numbers for the energy programs are from CPUC documents.[41] The numbers for the WUE program are discussed in detail in Appendix C. The energy savings were assigned to Northern and Southern California based upon their respective populations. The cost of water efficiency measures assumes an average of $384 per acre-foot, based on a range of $58-$710.

There is clearly significant untapped energy savings potential in programs focused on water use efficiency. If all of the identified urban water savings could be achieved, the energy savings would achieve 95 percent of the savings expected from the 2006-2008 energy efficiency programs, at 58 percent of the cost. Peak savings could account for 60 percent of the utilities' expected demand reductions.

TOU Water Tariffs and Meters

The idea of TOU water tariffs and meters was suggested several times during the proceedings as a means to give customers a more accurate assessment of the value of the water they use. Historically, water agencies have treated their product as a commodity; water flows and people use it. Before the 2000-2001 energy crisis, even though water agencies were on standard TOU and demand rates, the incremental costs between on and off peak were not large enough to affect their decision making. They did not attach time value to water until SWP and the state water contractors became sensitized to hourly energy costs in the highly volatile bulk power market. At the retail level, it is important to recognize that many water customers in the state do not even have water meters, although legislation is changing that. Currently, TOU water meters do not exist. Water agencies are also grappling with how to develop tariffs and rate schedules that both properly reflect the value of water at different times during the day and account for delays between

[41] 2004-2005, CPUC Rulemaking R.01-08-028, Decision D.03-12-060, 2005-2006, CPUC Rulemaking R.-01-08-0228, Decision D.04-09-060.

energy consumption and water use. The Energy Commission is funding a project to look at the feasibility of these meters and associated tariffs.

Because the vast majority of the financial benefits of water use efficiency go to customers instead of water, wastewater, or energy utilities, informing customers of the financial upside of more efficient appliances and practices could be very effective. The new "Flex Your Power at the Tap" campaign is one example. In the longer term, water and energy bills could also serve as informational pathways leading customers to efficiency investments and choices that are best for both them and the greater society.

Water Storage for Peak Electric Load Shifting

Water and wastewater treatment require approximately 3,000 MW of peak load. There is a minimum level of electrical consumption needed to operate their systems during peak periods. Beyond that, virtually all of the on peak energy use is discretionary - if there is sufficient storage. For example, the El Dorado Irrigation District reduced its on-peak electric usage by more than 60 percent by allowing their tanks to drop to a lower minimum level and installing an additional 5-million-gallon storage tank. An estimated 250 MW of peak demand could be saved if water agencies statewide viewed their storage as an energy asset as well as a water asset. Another 1,000 MW of peak demand could be saved from increased treated water storage in urban areas. In total this represents more than one-third of the water use cycle load.

Investing in Water and Energy Efficiency

California has water-related energy programs to increase the energy efficiency of existing water and wastewater utility operations; increase the energy efficiency of the appliances that move water; and increase generation from renewable resources. These programs include building and appliance standards, technical support and loan programs, and incentive programs funded through the state’s energy utilities. The state also conducts research to modify existing treatment processes; develop more efficient water and wastewater treatment and water supply technologies; increase the efficiency of heating, cooling, and moving water for end users; and improve the effectiveness of renewable energy sources.

However, since the state’s largest energy utilities have no authority to invest in programs that save cold water to capture the upstream energy benefits, these benefits are not realized. If the CPUC authorizes investment in cold water savings, the state will have a new source of energy savings.

Because of the interconnectedness of water and energy resources in California, the fact that cost-effectiveness is determined solely from a single utility and single

resource perspective is a glaring problem. Water utilities value only the cost of treating and delivering water. Wastewater utilities value only the cost of collection, treatment and disposal. Electric utilities value only saved electricity. Natural gas utilities value only saved natural gas. This causes underinvestment in programs that would increase the energy efficiency of the water use cycle and increase agricultural and urban water use efficiency.

By valuing a unit of water on its total value – the water resource itself, plus its energy intensity and externalities throughout the entire water cycle -- many water and energy programs and measures that could not meet the earlier cost-effectiveness threshold are now possible. California could reap large energy benefits by encouraging greater collaboration between energy, water, and wastewater utilities.

Conclusions

In this chapter, staff has generally described the water energy intensity for agricultural and urban end uses. Staff recommends additional research to provide needed information to better understand these systems and how modifications or improvements could benefit the energy sector. Future regulatory change will also affect the overall energy demand of these systems. To ensure high-quality water supplies for the state, energy and water utilities should collaborate to efficiently operate water and wastewater treatment facilities. Water and wastewater utilities can take advantage of current energy efficiency programs for near-term retrofits and design modifications to increase efficiency now, with existing technology. Additional research is needed on technologies and system designs.

CHAPTER 5 – RENEWABLE ENERGY GENERATION POTENTIAL

The most widely recognized aspect of the water-energy relationship is power production in large scale hydroelectric dams. However, water and wastewater utilities have other opportunities to develop energy supplies. These include biogas cogeneration at wastewater treatment plants and development of local renewable resources on water and wastewater utilities' extensive watersheds and rights-of-way. For purposes of this paper, we will address the potential for new renewable generation by water and wastewater utilities for two distinctly different types of opportunities:

- Distributed generation
- Utility scale generation

These energy generation opportunities require different types of permits, approvals, metering, and interconnections, and have different production characteristics, economics, and operating and financial risks. Detailed aspects of distributed generation and large-scale hydroelectric generation are addressed separately in the *Energy Report*. [42]

Table 5-1 illustrates the range of renewable power production opportunities for water and wastewater utilities.

Table 5-1: Renewable Power Production Opportunities

Energy Resource	Distributed Generation	Utility Scale Generation
Hydropower	Energy Recovery through In-Conduit Hydropower	▪ Relicensing ▪ Pumped Storage ▪ Repowering
Biogas	Biogas Co-Generation	Biosolids Waste-to-Energy plants that utilize methane from sewage digesters, dairy manure, agricultural and food processing wastes, and other organic materials
Solar	Photovoltaics for irrigation pumps & motors	Central concentrating solar power plants (solar thermal and photovoltaics)
Wind	Modest site specific applications	Wind farms on watershed lands
Advanced Generation, including Fuel Cells and MicroTurbines	Potential applications for small pumping loads	n/a

[42] For a complete listing of all documents and reports associated with the IEPR proceeding, including distributed generation, please see [http://www.energy.ca.gov/2005_energypolicy/documents/index.html].

The potential, issues, and challenges of these opportunities are discussed below.

Distributed Generation

The term distributed generation is used to describe both customer-side and utility-scale generation. For purposes of this staff report, distributed generation refers to generation facilities sited on the customer side of the meter that are used primarily to serve a customer's own energy requirements, specifically a water or wastewater utility. This discussion is limited to opportunities for water and wastewater utilities to self-generate power, and the barriers and hurdles that prevent them from generating more. These facilities include in-conduit hydropower, biogas combustion, and other small-scale distributed generation facilities.

In-Conduit Hydropower

Wherever there is flowing water, there is both energy and the potential to capture and utilize that energy. In-conduit hydropower captures the energy from flowing water in a pipeline with a turbine or generating device installed directly in the conduit. Most of the state's large water conveyance projects already take advantage of the energy in water flowing through their pipelines, canals, and aqueducts. Additional opportunities remain to develop new or retrofitted generation in the state's water systems, if costs and risk can be minimized. These are environmentally attractive because they are built in existing water and wastewater systems.

In most cases, in-conduit hydropower potential ranges from very small – 1 or 2 kW to a high of about 1 MW. Often, the hydropower site is not near loads, requiring construction of expensive transmission or distribution lines to interconnect to the electric system. Even in cases where it may be cost-effective to construct such lines, existing rules do not allow the produced power to be credited against the water or wastewater utility's total energy bills. Instead, wherever such self-produced power cannot be directly connected to an existing load, it must be sold into the wholesale bulk power market. The costs and complexities of participating in the wholesale bulk power and transmission markets are daunting, even for large generators. They are prohibitive for very small generators.

A recent Energy Commission Public Interest Energy Research (PIER) study estimated the statewide developable potential of hydropower capacity in manmade conduits (including pipelines, irrigation ditches, canals and aqueducts) at about 255 MW - 231 MW at coincident peak - with annual production of approximately 1,100 GWh. The potential was about evenly split between municipal and irrigation district systems.[43]

[43] *California Small Hydropower and Ocean Wave Energy Resources*, Mike Kane, Energy Commission PIER, April 2005.

The PIER study focused on identifying the statewide potential for RPS-eligible small hydropower (less than 30 MW). Under SB1078, RPS-eligible hydropower must be constructed on or after September 12, 2002, and must not require a new diversion or a new appropriation of a water right.[44] Consequently, staff determined that the most likely class of hydropower to be developed under the present RPS is small hydropower within conduits. The PIER study only considered sites with potential of at least 100 kW since projects of lesser size tend to be uneconomic.

Changes in technology may reduce the economic threshold of in-conduit hydropower to less than 100 kW. New packaged systems are being developed that could be dropped into pipelines and other types of conduits – like canals and aqueducts - without expensive civil works or permitting costs. However, the challenge of siting in-conduit hydropower close to local loads remains.

Another way to look at in-conduit hydropower is to view it as an increase in the energy efficiency of the water delivery system. Without water agency investment in the water delivery system in the first place, this resource would not be available. Currently in-conduit hydropower is treated like any conventional energy generation resource owned and operated by a non-utility generator. This classification seems inappropriate since there is no prime mover and no new natural resource is used to generate the electricity.

Existing energy efficiency programs can be tailored for special circumstances, using customized incentives and standard performance contracting. Water agencies have taken advantage of these incentives for energy efficiency improvements, including increasing pipe diameter to reduce friction losses and the requisite pumping requirements; installing a parallel pipe system; and changing pump impellers and lining pipes to reduce friction losses. In-conduit hydropower could be looked at in a similar fashion and be included as an element of these tailored programs. Again, the issues of interconnection and the sale or application of the power to multiple accounts will still need to be addressed.

Biogas

Another option for developing generation in the water sector is to increase beneficial use of digester gas produced by the sewage wastewater, dairy manure, and food processing wastes/wastewater. Biogas, primarily composed of methane, can be used for a combined heat and power production.

California has 311 sewage wastewater treatment facilities, 2300 dairy operations, and 3000 food processing establishments. Currently, about 50 percent of sewage sludge, 2 percent of dairy manure, and less then 1 percent of food processing wastes/wastewater generated in the state are utilized to produce biogas. Converting

[44] *Renewables Portfolio Standard Eligibility Guidebook*, Energy Commission Publication Number 500-04-002F1, adopted August 11, 2004.

these wastes into energy can help operating facilities offset the purchase of electricity and provide environmental benefits by reducing air and groundwater pollutants discharged.

Unused biogas is typically flared to the atmosphere. Not only is this a waste of a renewable resource – flared biogas creates odors and air emissions.

Biogas producing facilities can be near significant loads, for example the wastewater treatment plant itself. However, this load may be on multiple meters and current rules discourage full use of the available biogas for maximum generation for onsite or offsite loads. Currently, there are provisions under regulated tariffs that enable dairy operations to produce electricity from biogas resources at one location and use it to offset electricity use at multiple locations, under multiple accounts, for one customer. This same approach would significantly increase opportunities for biogas-fired (and other renewable) generation in water and wastewater agencies.

The Inland Empire Utilities Agency (IEUA) is a leader among regional wastewater treatment agencies for innovative and proactive energy management. IEUA's facilities process 65 million gallons of wastewater into high-quality recycled water. IEUA's wastewater treatment system has three anaerobic digesters. Dairy manure is collected from seven nearby dairies and processed through two of IEUA's digesters. At one facility, biosolids from the sewage treatment process are combined with dairy manure. At another facility, dairy manure alone is used to produce the methane that is piped to the Chino Basin desalter, where it is used to produce electricity for desalination of groundwater.

IEUA believes there is significant potential for increasing biogas production by combining different types of biosolids. For example, by blending dairy manure with food waste, IEUA expects this year to double its amount of biogas production (from 0.5 MW to the total load of the Chino desalter of 1 MW).

IEUA's biogas power production is expected to continue to grow as it adds another 15 MGD wastewater treatment plant next year, and it plans to develop another 10 MW in renewable biogas generating capacity with a centralized biodigester that will take dairy waste, green and food residuals (generally used to make compost) and biosolids to produce biogas for power generation and compost. IEUA is also considering using its excess biogas to heat water and sell a new product, hot process water, to industrial customers.

While IEUA has been much more successful than other wastewater utilities in the innovative development of biogas power production, it has not been simple.

Other Distributed Generation Options

Other distributed generation options include solar thermal, photovoltaics, small wind power, and advanced generation technologies including fuel cells and advanced

microturbines. These distributed generation opportunities are discussed at length in the *Energy Report* proceeding.

Utility Scale Generation

Many water and wastewater utilities have the opportunity to develop utility-scale power production facilities that produce more power than utilities need for their own processes. With technical and funding support and removal of major barriers, water and wastewater utilities could become net exporters of power. Whether conventional hydropower facilities developed in conjunction with large water conveyance systems - like the Oroville Hydroelectric Facility, owned and operated by DWR on behalf of the State Water Project, or wind farms constructed on watershed lands – substantial untapped renewable resource potential resides with water and wastewater utilities that have little incentive, and, in fact, many barriers and disincentives, to develop these resources.

Large-Scale Hydropower

In addition to the in-conduit hydropower opportunities described above, utility scale generation consists of conventional hydropower (less than 30 MW) produced by water releases from natural or manmade impoundments like reservoirs and dams.

Opportunities for new hydropower dam and storage projects are extremely limited in California for a variety of reasons. Most economically viable sites have already been developed; but even where suitable sites exist, development is limited by lack of availability of unallocated water rights, environmental protection measures (such as Wild and Scenic Rivers, Endangered Species, and Wilderness Area designations), and strong opposition from environmental advocates.

Staff has investigated ways to balance the electric system benefits offered by hydropower with their significant adverse environmental impacts. Both the Energy Commission's *2003 IEPR*[45] and staff's *California Hydropower System: Energy and*

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[45] *2003 Energy Report*. California Energy Commission, *2003 Integrated Energy Policy Report*, December 2003, Docket No. 02-IEP-1, Publication No. 100-03-019, page 43.

> "Hydroelectricity has historically played an important role in meeting California's electricity needs. Its low production costs and unique ability to meet critical peak demand have long benefited the state's ratepayers. Some hydroelectric projects unfortunately have serious environmental consequences, such as significant, ongoing impacts to many California rivers and streams, native salmon and trout populations, and the water quality needed to support sustainable riverine ecosystems.
>
> The restoration of imperiled salmon and trout fisheries is one of California's environmental policy objectives. ... [D]ecommissioning of high environmental impacts hydroelectric facilities that supply little power is a possible method of restoring important aquatic habitat."

Environment[46] provide key findings with respect to hydropower's value and impacts. Staff provides recommendations to minimize the adverse environmental impacts of these facilities.

At this time, only two utilities are expected to develop hydroelectric resources. [47] The Sacramento Municipal Utility District (SMUD) proposes the Iowa Hill Project to add 400 MW of pumped-storage capacity to its Upper South Fork American River Project. This may be especially helpful for integrating wind energy produced in the Delta, since the Delta breeze on a hot summer day usually begins a few hours after the daily load peak, which is driven by air conditioning. For San Diego Gas and Electric (SDG&E), about 40 MW of new hydro are planned, beginning in 2008, from San Diego County Water Authority projects.

Long lead times are needed to plan new hydro projects, prepare appropriate environmental documents, obtain a license from the Federal Energy Regulatory Commission (FERC), and build the project. However, opportunities for incremental development, such as adding or improving generation facilities attached to existing dams, water conveyance facilities, and powerhouses, remain an option for increasing California's hydropower production.[48] These opportunities include pumped storage and retrofit.

Pumped Storage

Pumped storage typically involves pumping water from a water source into a reservoir or tank, to be held for later scheduled hydropower production. Water is pumped uphill during off-peak hours and provides peaking capacity during on-peak hours. Pumped storage has high energy value since it is virtually the only viable means to store energy. There are several significant pumped storage projects currently under development:

- The proposed 500 MW Lake Elsinore Advanced Pumped Storage Project (LEAPS)[49].

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[46] California Energy Commission, *California Hydropower System; Energy and Environment*, Appendix D to the *2003 Environmental Performance Report*, prepared in support of the *2003 Integrated Energy Policy Report*, October 2003, Publication No. 100-03-018. Prepared in support of the *Electricity and Natural Gas Report* under the Integrated Energy Policy Report proceeding (02-IEP-01), October 2003, Publication 100-03-018.

[47] *California and Western Electricity Supply Outlook Report* Draft, California Energy Commission, July 15, 2005, pages 74-76, posted on the website of the California Energy Commission.

[48] Excerpt from the *California and Western Electricity Supply Outlook Report* Draft pages 74-76, in progress for posting to the website of the California Energy Commission, July 15, 2005. For information about California's overall hydropower outlook, please refer to the Energy Commission's 2005 report, *Potential Changes in Hydropower Production from Global Climate Change in California and the Western United States*, prepared in support of the *2005 Integrated Energy Policy Report* proceeding (Docket # 04-IEPR-01G).

[49] EVMWD Web site (www.evmwd.com).

- SMUD's proposed 400 MW Iowa Hill Pumped Storage Development.

- The US Bureau of Reclamation is also exploring several pumped-storage options in the Upper San Joaquin River Basin.[50]

As with any dam or reservoir, development of new pumped-storage facilities faces major challenges. Some of the issues associated with conventional hydroelectric power generation and typical on-stream pumped hydroelectric storage facilities include:

- Water resources impacts - hydroelectric facilities may change stream flows, reservoir surface area, the amount of groundwater recharge, and water temperature, turbidity, and oxygen content.

- Biological impacts, including the possible displacement of terrestrial habitat with a new lake environment, alteration of fish migration patterns, and other impacts on aquatic life due to changes in water quality and quantity.

- Possible damage to, or inundation of, archaeological, cultural, or historic sites (primarily if a reservoir is created).

- Changes in visual quality.

- Possible loss of scenic or wilderness resources.

- Increase in potential for landslides and erosion.

- Recreational resource impacts/benefits.

Another possibility for developing new pumped-storage projects is to connect two or more existing reservoirs or lakes with new pipelines or penstocks for water pumping and power generation. A U.S. Department of Energy (DOE) study identified dozens of such potential reservoir pairs in California, requiring construction of an average of about 10 miles of pipeline to connect each pair. (Lamont 2004). Though this type of development would increase operating flexibility and peaking capacity without need to construct new reservoirs, it would still involve construction of large pipelines through difficult terrain on protected lands, which could require significant expense for environmental mitigations and permitting.

Because of the costs associated with new pumped-storage facilities using existing or new reservoirs, development of modular pumped storage (MPS) may have greater potential in the near future. MPS systems are not dependent upon

[50] USBOR website 2005a.

natural waterways and watersheds and can be sited in areas that avoid many of the issues described above. In fact, they are generally purposely sited away from sensitive areas to avoid the regulatory and operational complexity often associated with conventional pumped hydroelectric storage facilities. MPS systems can also be added to existing water systems wherever the necessary elevation difference exists. They could also be developed in places like abandoned mines, taking advantage of elevation differences and storage created by mine shafts and open pits. If their capacity was less than 30 MW, these pumped-storage facilities could also qualify for supplemental energy payments under the RPS.[51]

Retrofit[52]

Retrofitting existing hydroelectric facilities, specifically replacing turbine runners and generators with new, more efficient equipment, may increase the capacity of these facilities. To the extent that retrofit does not result in changed flows, no permits may be needed. Hetch Hetchy Water and Power increased the capacity of its system 48 MW by replacing turbine runners and generators with newer, more efficient equipment – at a capital cost of $8 million, less than 17 percent of the cost of installing a new unit of comparable capacity. Since the purpose of these retrofits was to increase the efficiency of hydropower production using the same amount of flows, no permits or approvals were required.

Existing hydropower facilities can be upgraded to increase both capacity and output without changing flows. Below are the primary means for attaining such efficiency gains:

- Tunnels. Most power tunnels in California were built using drill and shot methods for rock excavation. The resulting rough rock linings have high friction losses and capacity issues. Existing unlined tunnels could be lined to decrease friction losses and produce more power with the same amount of water. Existing lined tunnels can be made smoother by relining or coating abraded surfaces. Some tunnels can be enlarged or made smoother by selectively trimming tunnel walls. The longer the distance of the tunnel and the greater the friction, the greater the opportunity for incremental gains in power production. Some tunnel lining projects have increased hydropower production up to as much as 7 percent.

- Penstocks and Pipelines. Similarly, penstocks and pipelines could be relined or replaced to reduce friction losses during times of high flows. The decision to reline or replace is an economic one that depends in large part upon the remaining useful life of the hydropower facility itself. The potential benefit also

[51] Aspen 2004
[52] Matthew Gass, Engineering Manager, Hetch Hetchy Water and Power, San Francisco Public Utilities Commission.

depends upon the length of the penstock or pipeline, and the amount of friction losses. Here, again, benefits of up to 7 percent have been documented.

- Turbines. The easiest and frequently most economical improvement could be to replace a turbine's runner. Computerized design, manufacture, and improved testing and modeling methods have increased the efficiency of turbine runners. Minimum efficiency gains for replacements of turbine runners installed in the 1970s and 1980s have been reported at 1 percent. When older designs are replaced by customized efficiency designs, increased output as high as 30 percent has been reported.

Other types of hydropower efficiency gains are attainable through improved planning, controls, and management. Most large hydropower plants in California are multi-unit facilities. In many cases, there are opportunities to optimize operations by balancing the loads of individual units. Specialized computer selection software has helped attain performance improvements of 1-3 percent. In addition, improved controls and monitoring systems allow more efficient operations and reduce downtime from unplanned outages. All of these things have potential to increase net power production. Applied to the state's hydropower inventory, these minor tweaks could cost-effectively increase the state's total hydropower production by at least 3 percent within just a few years.[53] However, FERC rules regarding system modifications and upgrades will need to be reviewed to confirm the trigger points that could reopen a license to scrutiny.

There is constant tension among competing interests for water supply, water quality, hydropower production, and flood control. A better understanding of opportunities for optimizing the state's hydropower supplies and the key stakeholders needed to attain those incremental benefits would provide a useful framework for identifying feasible options and resolving points of conflict.

Other Renewable Resources

Both water and wastewater utilities have extensive watershed lands and rights-of-way with potential for wind and solar development.

- In spring 2005, the Semitropic Water Storage District completed installation of a 1 MW solar facility that provides peaking power for local pump loads.[54]

- At the Solar Power 2004 Conference and Exposition, San Francisco announced that it will soon build a 225 kW solar facility covering 20,000 square feet at its Southeast Water Pollution Control Plant.

[53] Matthew E. Gass, P.E., Engineering Manager Hetch-Hetchy Water and Power.
[54] Boschman 2005..

- IEUA will install solar panels on its new LEED Platinum headquarters, which was designed to reduce energy use by 90 percent and water use by 70 percent compared with its previous building. IEUA expects its headquarters to be completely energy independent by next year.[55]

- Hetch Hetchy conducted a wind resource assessment of its Calaveras watershed that indicated a potential of more than 30 MW.

The developable renewable energy potential owned by water and wastewater utilities is not yet known. It would be beneficial to identify, assess and prioritize these resources, and provide technical and financial assistance to help develop renewable energy for the benefit of all California ratepayers.

Barriers to Energy Production

Even when transmission is available to move the power out of a water agency's conduit hydropower, biogas, or solar facility, the water professionals interviewed for this paper expressed frustration with their limited ability to deliver self-generated power to their various facilities. Water and wastewater facilities are often dispersed over large distances. These facilities typically take electric service at multiple points and are metered separately at each point.

During public workshops and working group meetings, water and wastewater utilities cited the following primary barriers to self-generation:

- Complex, costly and long lead time interconnections.
- Prohibitive stand-by costs.
- Disincentives to fully utilize available renewable or distributed resources.

Issues of interconnections are being addressed by both the CPUC and the Energy Commission with respect to Rule 21.

Present regulations do not allow aggregation of a customer's electric metered loads within a single facility, much less with metered loads at their other facilities. Therefore, the only means for a water or wastewater utility to deliver self-generated power to itself anywhere on its system is to own and operate its own transmission and distribution systems -- essentially, to operate its own electric utility contiguous with its water service territory boundaries. Of course, this would be cost prohibitive.

At the April 8, 2005, *Energy Report* Committee workshop, IEUA identified the following barriers to its efforts to become energy self-sufficient and possible solutions to these barriers (Table 5-2).

[55] Davis 2005.

Table 5-2: Barriers to Energy Self Sufficiency

Barrier	Solution
Presently, IEUA is metered at multiple points, making it difficult to understand, plan and manage its total energy requirements.	The ability to aggregate all of IEUA's electric loads into a single consolidated load would enhance IEUA's ability to self supply its loads. In addition, it would enhance IEUA's ability to develop creative approaches, whether through modified system design and/or operations, to further reducing peak period consumption.
CPUC "single premise rules" discourage building generation greater than connected load.	IEUA would increase the size of its generation facilities if it had ability to wheel self generated power to itself.
Energy utility programs often fail to capture opportunities to encourage energy efficient design principles in water agencies' facilities.	IEUA and other water agencies have substantial continuous capital programs and, thus, opportunities to incorporate non-conventional energy efficient design principles into large facilities. For example, most of the cost of a new or replaced pipeline is in the trenching. The incremental cost of oversizing a pipeline is fairly modest and should be encouraged wherever cost-effective in reducing energy consumption. Some Energy Performance Contracting programs can be accessed for these types of projects; but applying for and collecting incentives are often difficult.
IEUA and other water agencies have unique opportunities for renewable energy development (e.g., biogas; pipeline conduit hydro; extensive rights of way and watershed lands); but the development costs and risks are often daunting for an entity for which energy is not its primary business.	IEUA is hosting various pilot programs that test and refine renewable energy technologies. Energy utilities could partner with water agencies to optimize development of their renewable energy potential, first to offset their own loads, and then potentially to also become net exporters of renewables and help energy utilities meet RPS and achieve other environmental benefits, including greenhouse gas reductions. Incentive programs are key to testing new technologies at scale. Net metering program (SB 728) will be essential to capturing value of renewable energy.

Source: IEUA testimony

Conclusions

Given the state's energy and capacity shortages, it would be beneficial to help water and wastewater utilities develop all potential renewable and distributed resources. This can be facilitated by allowing these utilities to aggregate their metered load and remove net metering caps. Excess power could then be sold to the energy utilities. Ultimately, the tension between energy utilities and their customers needs to be resolved through policy. The fundamental issue is whether customer-sited distributed generation provides an energy system benefit that reduces total societal costs.

CHAPTER 6 – POTENTIAL EFFECTS OF FUTURE CHANGES

Several factors are causing changes to California's water supply portfolio; legislative, regulatory, market, and technological changes will affect both water-related energy consumption and energy production.

The following discussion addresses a variety of known and anticipated energy impacts, the primary drivers of these impacts, and the extent to which the magnitude and timing of these impacts can be predicted. The primary drivers to be discussed are:

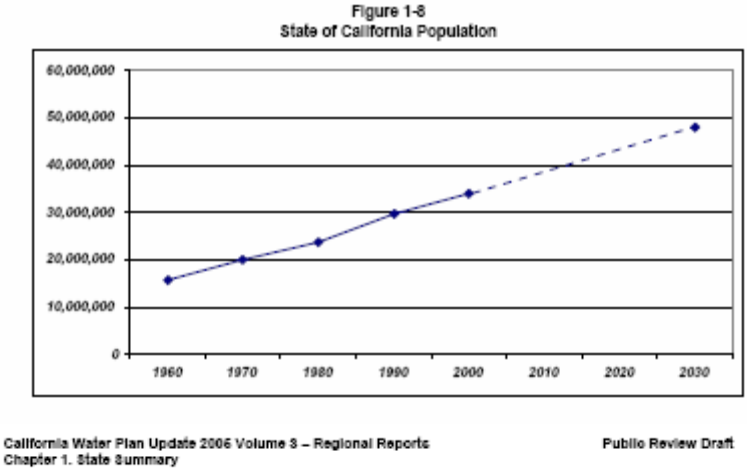
- Increased water demand
- Changes in water end use
- Changes in regulation and legislation
- Changes in water and energy markets
- Hydrology
- Technology
- Policy

Where reasonable bases exist for estimating these impacts, they will be described. If their impacts cannot be reasonably projected, staff identifies needed additional information.

Increased Water Demand

DWR, in the *2005 Water Plan Update,* based its estimates for water demand growth on data from the Department of Finance (DOF) that estimates California's population will increase more than 40 percent by 2030 - from about 34 million in 2000 to 48 million in 2030 (Figure 6-1). Absent mitigation, water-related energy consumption attributable to urban water use is expected to match this growth. The plan projects that, without mitigation, urban water use will increase substantially - as much as 6 million acre-feet, or 67 percent, by 2030.

Figure 6-1: Projected Population Growth in California



The actual impact of water demand growth on energy is difficult to predict for the following reasons:

1. The water supply portfolio planned to meet water demand growth is significantly different from the state's existing portfolio. Consequently, a simple extrapolation of the current average energy intensity of water supplies makes no sense.

2. The state water plan indicates that the largest new supply available to provide for the expected growth in water demand over the next 25 years is water use efficiency. To the extent that the state may not attain its targeted level of efficiency, any shortfalls in water supplies will need to be made up from other sources, most likely recycled water and desalination. Both of these options require new infrastructure that will need to be developed years before it is actually needed. If these are not in place in time, forced conservation, such as the shortage allocations during the 1987-1992 drought, may need to be implemented.

3. Industry experts predict there will be an increase in water market transactions. Some broad generalizations about water market transactions can be made. For example, to the extent that these transfers result in a net increase in physical deliveries of Northern California water supplies to Southern California or agricultural water use is converted to urban water use, energy consumption for water conveyance will increase. However, the net energy impact of increased water transactions cannot be determined. There are many variations in the types of transactions that could occur and no certainty as to which will or will not occur.

4. The recent Colorado River Quantification Settlement Agreement (QSA) requires that California beneficiaries of Colorado River water reduce their use over the next 14 years to California's basic annual allocation of 4.4 million acre-feet. A number of specific actions are being taken by Southern California water utilities to implement the QSA and make up for reductions in Colorado River imports.

Strategies include increased water use efficiency, increased imports from the State Water Project, development of 126,000 acre-feet of desalinated ocean water, managing the San Bernardino Basin as a groundwater facility, increased use of recycled water, and paying farmers to fallow their land. It seems likely that these strategies will have significant impacts on energy use. However, the net impacts of all of the combined strategies and any offsets, such as reduced energy due to lower Colorado River imports, are not yet known.

In order to assess its range of potential impacts, staff estimated the energy implications of the water supply portfolio strategy illustrated by DWR for low and high growth scenarios. Table 6-1 shows that energy associated with the water plan strategy will increase water sector energy use by 12.3 percent in the low-growth scenario, to as much as 25.8 percent in the high-growth scenario, over the period 2000 to 2030. The energy impacts were derived by multiplying the energy intensity numbers for each type of incremental water source from Figure 2-2 in Chapter 2, by DWR's projections.

Table 6-1: Estimated Energy Impacts of Proposed Incremental Water Supplies[56]

	Low Growth Projection				High Growth Projection			
	Water		Energy		Water		Energy	
Resource	MAF	%	GWh	%	MAF	%	GWh	%
Conjunctive Management	0.5	21.3%	475	19.2%	2.1	36%	1,995	40%
Recycled	0.9	38.3%	352	14.2%	1.4	24.1%	547	11%
Surface Storage	0.05	2.1%			1.0	17.2%		
Inland - Desalter	0.2	8.5%	340	13.7%	0.3	5.8%	570	11%
Ocean - Desalter	0.1	4.3%	440	17.8%	0.2	2.8%	726	15%
Conveyance	0.3	12.8%	870	35.1%	0.4	6.9%	1,160	23%
Precipitation Enhancemer	0.3	12.8%			0.4	6.9%		
	2.35	100.0%	2,477	100.0%	5.8	100.0%	4,998	100.0%
Current - Base	43		19,345		43		19,345	
Total Projected	45.35	5.5% Growth	21,822	12.8% Growth	49	13.5% Growth	24,343	25.8% Growth
Water Use Efficiency								
Urban	1.1				2.3			
Agriculture	0.2				0.9			
Total	1.3				3.2			

Source: 2005 State Water Plan Update, DWR for water projections. Appendix C for energy calculations

DWR's plan calls for urban and agricultural water use efficiency to make the largest contribution to the state's water supplies. However, conserved water will be redistributed to new users as the population increases. Recycled water, planned to provide almost 40 percent of incremental water supplies in the low-growth projection, will contribute 14 percent to incremental energy use. At the other extreme, ocean desalting is planned to provide only 4 percent of the incremental water, but will require almost 18 percent of the energy. These estimates are indicative of the need to better understand the energy implications when developing the state's future water supply portfolio.

[56] Low-growth projections reflect a 2030 water demand scenario where current trends continue, resulting in reduced agricultural irrigated crop area and reduced agricultural production. Urban water demand increases are linked to population increases and corollary increases in employment sectors. Under this scenario, per-household as well as per-employee water demand decreases slightly. Environmental water demand increases, and naturally occurring conservation decreases slightly. Population growth is based on Department of Finance (DOF) 2004 projections for growth and density.

High-growth projections reflect a 2030 water demand scenario where agricultural irrigated crop areas hold constant with year 2000; urban related water demand grows significantly, linked to population growth exceeding DOF projections by 12 percent, and lower overall population density and greater population growth occurs in inland and in southern hydrologic regions. Per-household and per-employee demand is elevated, and naturally occurring conservation decreases slightly. Urban water prices continue current trends.

Changes in Water End Use

A number of factors are driving changes in water end use. Changes impact both the urban and agricultural sectors. There are many types of changes – some that may increase energy consumption and some that may decrease energy consumption. Net impacts are difficult to predict. The discussion below about changes in agricultural water use illustrates the complexity of evaluating the net energy impacts of changed water use patterns.

Changes in Agricultural Water Use

As discussed in Chapter 4, changes in crops and irrigation methods affect overall energy demand. In the future, staff expects that periodic changes in crops will occur. Staff cannot predict what those changes will be. Consequently, only general statements can be made about the energy impacts of different trends. The *California Water Plan* projects that the agricultural sector will reduce overall water demand, predominantly through conservation. Any saved agricultural water will likely be applied to higher energy intensity urban uses.

Other signs point to decreased energy use in the agriculture sector, including efforts to conserve water and energy, following the example of urban agencies that universally follow a set of BMPs in managing their systems. For example, some irrigation districts have signed on to a program sponsored by DWR that requires implementation of Efficient Water Management Practices (EWMPs) that address energy management (Efficient Water Management Practices by Agricultural Water Suppliers in California, Memorandum of Understanding, January 1, 1999). That effort was prompted by the Agricultural Water Suppliers Efficient Water Management Practices Act of 1990. However, unlike urban water systems where water conservation also brings energy conservation, agricultural water conservation can often lead to increased energy demand. Reuse of tailwater, for example, requires installation of additional pumps, and drip and microspray irrigation need more electricity than other irrigation methods. Some of these uses, however, such as reuse of tailwater, could have the benefit of avoiding long-distance conveyance energy use.

Utilities and agencies are also addressing agricultural energy use through several energy efficiency programs. A good example is the Agricultural Pumping Efficiency Program (APEP), run by the Center for Irrigation Technology, which is part of the California Agricultural Technology Institute at the College of Agricultural Sciences and Technology, California State University, Fresno. The program receives funding from the Public Goods Charge on utility bills and provides free pump efficiency evaluations for farmers and irrigation districts served by the state's three large investor-owned utilities. Since 2002, the program has resulted in at least 15 GWh of savings from approximately 350 pump retrofit/repair projects.[57]

[57] Canessa 2005

Taken together, no definite conclusion can be drawn concerning the future trend of energy use in the agricultural sector. It is necessary to look at all applicable portions of the water use cycle when assessing the net energy impacts. More work is needed.

Changes in Regulation and Legislation

There are a number of regulatory and legislative actions that will impact both energy consumption and energy production by the water sector.

Water Quality Regulations

Energy use for water treatment will increase as more stringent water quality rules are implemented under the federal Safe Drinking Water Act. These new rules require multi-stage disinfection including treating potable water more than once, which ensures removal of harmful organisms that may grow during storage and transport, and improved disinfection technologies that reduce the risk of carcinogens and other potentially harmful disinfection by-products. These improved disinfection technologies – principally, ultraviolet treatment and ozonation[58] – are much more energy intensive than prior chemical methods.

Energy use for wastewater treatment is also expected to increase because of new requirements under the Clean Water Act for treating effluent before discharging it into natural waterways. However, by increasing the quality of wastewater effluent, more recyclable water can be added to the water supply portfolio. Therefore, any increased energy use for wastewater treatment may be accompanied by a decrease from increased use of low energy intensity recycled water that can be used to displace higher energy intensity water supplies.

The actual impact of these new regulations is not yet known, and water agencies are still making decisions as to which treatment processes and technologies to adopt. In addition, the net impacts need to be better understood. However, a 2002 EPRI study estimated that these new water quality rules could increase energy consumption by wastewater treatment facilities by 20 percent between 2000-2005 and another 20 percent between 2006 and 2050.[59]

FERC Relicensing

FERC licenses 119 hydropower projects in California representing 11,930 MW, or 85 percent of the state's hydroelectric capacity. Thirty-seven percent of the state's entire hydropower system, totaling 5,000 MW, will be relicensed by 2015.

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[58] Ozonation requires about twice the amount of electricity used by chloramination to disinfect the same quantity of water. In addition, the requirement for multi-stage disinfection increases the number of processes and overall electricity use.

[59] *Water & Sustainability* (Volume 4): *U.S. Electricity Consumption for Water Supply & Treatment – The Next Half Century*, EPRI, March 2002.

Typically, the FERC relicensing process results in increased requirements for in-stream flows. This has the result of decreasing overall hydroelectric generation. The National Hydropower Association reported a decrease of about 8 percent on average for the nation as a whole. The California experience has been less – a loss of about 2 percent in in-state hydroelectric energy production to date. An odd twist is that hydroelectric capacity actually tends to increase during FERC relicensing, as old units are either repowered or replaced.

In its *2003 Integrated Energy Policy Report*, the Energy Commission reported findings from analyses of six projects being relicensed. The analyses included studies of changes in energy capacity and production from the perspective of statewide and regional electricity supply adequacy and the reliability and cost of replacement power that would result if the proposals were implemented. The study concluded that combined annual energy production losses from relicensing would represent approximately 1 percent of the state's total annual hydroelectric production. The study concludes that "Specific decommissioning proposals would need to be fully evaluated on a case-by-case basis to identify potential local area reliability effects."[60]

Both the Energy Commission's *2003 IEPR* and staff's *California Hydropower System*: *Energy and Environment* provide key findings, as of October 2003, with respect to the potential energy and environmental impacts of FERC hydroelectric relicensing.

[60] California Energy Commission, *2003 Environmental Performance Report*. Appendix D, *California Hydropower System: Energy and Environment*, Sacramento, CA. 100-03-018, March 2003, p. D-4.

2005 Energy Policy Act

The 2005 Energy Policy Act (EPAct) recently signed into law by President Bush contains significant provisions that could affect both water-related energy use and production.

Water-Energy Relationship

- Funding for research, development, demonstration, and commercial applications to address water-energy issues including energy-related issues in optimal management and efficient use of water, and water-related issues in optimal management and efficient use of energy [Section 979].

Hydropower Incentives

- Ten-year production incentive payments for hydroelectric power from generation additions to existing dams or conduits completed within the next 10 years, limited to $750,000/year per facility [Section 242].

- Incentive payments for up to 10 percent of capital improvement costs for hydroelectric facilities that increase efficiency by more than 3 percent, not to exceed $750,000 per facility [Section 243].

- Inclusion of qualifying hydropower production (due to efficiency gains or capacity expansions placed in service after the date of the Act and before 2008) for Section 45 tax credits [Section 1301].

Other Renewable Energy Technology Development & Incentives

- Funding of more than $2.2 billion for fiscal years 2007-2009 for research, development, demonstration, and commercial application on renewable energy issues, including efficiency, cost and diversity, addressing a variety of renewable energy technologies (solar, wind, geothermal, hydropower, and other technologies) [Section 931].

- Funding of more than $750 million for fiscal years 2007-2009 to support a program of research, development, demonstration, and commercial applications for distributed energy resources and systems reliability and efficiency [Section 921].

- Funding for a State Technologies Advancement Collaborative (STAC) to research, develop, demonstrate, and deploy technologies where there is a common federal and state renewable energy interest [Section 127].

- Extension of in-service date deadlines to October 1, 2016, for facilities to receive renewable production incentive payments for solar, wind, biomass,

geothermal, plus the addition of landfill gas, livestock methane, and ocean-related energy resources [Section 202].

- Extension of in-service date deadlines for two years, to December 31, 2007, for renewable energy production tax credits under Section 45 of the Internal Revenue Code of 1986 for qualifying facilities: wind, closed and open-loop biomass, geothermal, small irrigation power, landfill gas, and trash combustion [Section 1301].

- An increase in the Business Solar Investment Tax Credit, from 10 percent to 30 percent [Section 1337].

- Amendment of the Public Utilities Regulatory Policy Act (PURPA) of 1978 to add the requirement that each electric utility shall make available to any electric consumer a net-metering service relative to an eligible on-site generating facility [Section 1251].

Where significant tax incentives exist, there is the opportunity to develop public-private partnerships that bring private investment to help develop renewable energy resources. The impacts of the 2005 EPAct on renewable energy development of water and wastewater utilities' resources and assets cannot be determined.

Changes in Water and Energy Markets

Changes in both water and energy markets have potential to impact energy consumption and production by the water sector. For both, the primary driver of change is economics.

Water Markets

California's water markets are changing. The ability to sell water under some circumstances without losing water rights will likely increase transactions. The provisions of the Colorado River Quantification Settlement Agreement are driving Southern California water utilities to make changes in their water supply portfolios. Further, changes in the mix of crops being planted in California and economic pressures to convert agricultural land to urban use will affect water-related energy consumption.

As discussed previously, because the wide variety of potential transactions, it is difficult to project the net impacts of water market transactions on future energy use. Not all water transactions result in more transported water. Transactions often involve exchanges of water rights among multiple interconnected parties that merely allow the downstream purchaser to take more water from existing sources for a price that compensates each party involved in the transaction. The transaction can sometimes result in a net energy benefit, especially when reducing SWP or other energy intensive imports.

Energy Markets

The 2005 Energy Policy Act will certainly have an impact on the pace and types of renewable energy development. In addition, other impacts - natural gas and diesel price volatility, the impact of competition for renewables to meet RPS goals, and the cost of bundled versus unbundled delivered energy to various load centers - will all affect how agriculture and water and wastewater utilities use energy.

One example is the agricultural pumping switch from diesel to electric. Thousands of diesel-powered pumps are now operating in the Central Valley. With diesel prices soaring and air quality rules tightening, farmers are being encouraged to consider switching back to electric motors. ITRC estimates that converting all of those diesel engine pumps back to electric would increase energy consumption by 1,131 GWh (ITRC 2003). On August 1, 2005, both PG&E and SCE's "AGICE" (Agricultural Internal Combustion Engine) incentive programs went into effect. They are available to owners of pumps of 50 horsepower and above, provide a 20 percent discount over other agriculture rates, increase at 1.5 percent per year until eliminated, and offer an environmental adder that will reduce the costs to the customer of extending distribution lines to the pump. PG&E's program is capped at $27.5 million per year in total incentives, including discounts and environmental adders.[61] SCE's program is capped at $9.2 million. In the PG&E territory, it is possible that 200-300 MW of new coincident peak will be added to its system during the course of the two-year open enrollment period.[62].

Hydrology

There are two primary types of hydrological conditions that could affect both energy consumption and energy production by water and wastewater utilities: drought and climate change.

Drought

Changes in hydrology significantly affect the availability of water supplies and water use from year to year. The worst case scenario, from both a water supply and energy perspective, is a multi-year drought. During past droughts, surface water deliveries dropped in some places to less than half of average year deliveries, forcing water users to rely much more on groundwater pumping and emergency conservation measures.

During prolonged droughts, certain types of electricity use increase. For example, when surface water supplies are low, more groundwater is pumped. During

[61] Mayers, 2005
[62] Keith Coyne, PG&E, August 4, 2005

sequential dry years, water must be pumped from even greater depths as aquifer levels fall. Periods of drought also significantly increase pumping from existing and future conjunctive use field, as agencies tap emergency water supplies. An extended multi-year drought could also spark the rapid development of additional desalination facilities.

Estimating the water-related energy impact of a multi-year drought, however, is more complicated than simply adding up projected increases of energy consumption. During droughts, water shortage policies and plans place limits on water use by various market sectors and customer groups to allocate limited supplies. In addition, SWP and other large water systems will not have as much water to pump. The combination of these impacts would need to be netted out against incremental energy consumption for water supplies - like groundwater pumping and desalination - to understand the true energy impacts.

In evaluating water-related energy consumption from prior years, staff has been unable to find data that definitively support the premise that water-related energy consumption increases during dry years. In general, staff can say that an increase in water-related consumption and a decrease in energy supply are likely during a dry year. However, water industry experts are divided as to whether there is a net positive or net negative impact in energy consumption during a prolonged multi-year drought where serious reductions in water storage could trigger mandatory water use reductions.

Climate Change

A change in the patterns of rain and snow could have significant effects on both electricity production and consumption. Climate change scenarios show that global warming trends may result in more rain, but less snow. As a result, even when total precipitation is near normal levels, spring runoff will likely occur earlier in the year, resulting in early “spills”[63].

The Energy Commission has already conducted substantial research into the effects of climate change and is taking a lead role for the state in developing strategies to reduce greenhouse gas emissions. These efforts, as well as other statewide studies, were summarized in two recent Energy Commission reports prepared in support of the *2005 Integrated Energy Policy Report*. The first report, *Climate Change Impacts and Adaptation in California,* summarizes available scientific literature and provides a brief overview of the research agenda. The second report, *Global Climate Change*, provides background and context to guide the formulation of policy options for reducing greenhouse gas emissions in California.

[63] Overfilling of reservoirs in spring months, with spills bypassing turbines and reducing energy production and sometimes, also reducing summer peaking capacity.

A third report, *Potential Changes in Hydropower Production from Global Climate Change in California and the Western United States,* evaluated the potential effects of climate change on hydropower operations and production. This study included the following findings and recommendations:

- Climate change studies to date have depended upon broad trend analyses and are not yet useful in predicting impacts at the local watershed level.

- California is experiencing a warming trend. This could precipitate earlier snowmelts, reduce summer hydropower production and capacity, and increase summer air-conditioning loads.

- Although more work is needed to predict local impacts, warmer temperatures could cause earlier snowmelts, reducing stored water supplies.

Reduction of stored water has several potentially adverse impacts:

- Less availability of surface water supplies (which could lead to increased use of more energy intensive supplies).

- Less hydropower peaking capacity.

- Lower head (reducing hydropower energy production as well).

Clearly, climate change impacts will need to be studied over many years before the true net impacts on both energy consumption and energy production can be accurately measured.

Technology

Changes in technology could change energy consumption and energy production, though the net impact of such changes is undeterminable. Below are some examples of potential changes in technologies that could affect water-related energy consumption or energy production:

- In addition to continually seeking more efficient water and energy systems and processes (e.g., desalination and disinfection technologies), research continues into streamlining system processes and plant designs.

- In addition, research continues into improving the efficiency of pumps, motors, and equipment to reduce energy consumption and increase operating flexibility to shift loads off-peak.

- Specific research into modifying the reverse osmosis process used in desalination to reduce energy requirements is occurring in multiple forums.

- New technologies are improving the design of turbine runners, making it possible to increase both capacity and output of existing hydropower systems through retrofits. In addition, research continues into developing packaged systems that can be dropped into existing pipelines without need for costly civil works and low head turbine technologies.

- Automated controls technologies also optimize water releases to better balance hydropower production with water supplies and electric loads, and allow more efficient pumping in water and wastewater treatment plants.

The American Water Works Association Research Foundation (Awwa-RF) and PIER are already collaborating on a portfolio of research and development projects related to the interdependencies of water and power.

Policies

Several policies have been adopted for both the water and energy sectors. Policies to reduce water and energy consumption will certainly impact both the water and energy sectors, but the net energy benefits may differ. Energy demand could go up as a result of water decisions. Ultimately, it matters tremendously what policy options are implemented and how well these policies are coordinated for mutual water and energy benefits. Thoughtful policies can mitigate the potential adverse impacts of water decisions on energy resources and infrastructure.

Conclusions

The common theme of all of these potential changes is that there are both threats and opportunities. In order to better understand these and develop plans and measures that leverage opportunities and mitigate threats, more information is needed by water and energy policymakers and implementing entities. Ultimately, the *net* energy impacts of various water policies and strategies need to be well understood in order to tailor effective mitigation measures.

CHAPTER 7 – STAFF RECOMMENDATIONS

Findings

During these proceedings, state and federal agencies, water and energy utilities, industry associations, research organizations, and a wide variety of other stakeholders came together to consider the state's water-energy relationship and what it means to the state's energy resources and infrastructure. While acknowledging there is much yet to be learned about the nature and extent of the state's water-energy relationships, some things are clear.

- The relationship between the water sector and the energy sector is complex and highly interdependent.

  - ✓ In-state hydroelectric power generation in 2004 accounted for approximately 11 percent of the state's in-state energy resources. When hydropower imports from the Pacific Northwest and the Desert Southwest are included, hydropower accounted for as much as 15 percent of the state's energy in 2004.

  - ✓ The water sector is the largest consumer of energy in California, estimated to account for 19 percent of total electricity and 32 percent of total natural gas consumed in the state.

- Saving a unit of water reduces the amount of energy used to collect, treat, deliver it, consume it, treat it, and dispose of it as wastewater. If used elsewhere, this saved water may displace the need to develop new, more costly water sources.

  - ✓ With few exceptions, the avoided energy value embedded in a unit of water throughout the applicable portion of the water use cycle is not accounted for by either water or energy utilities.

  - ✓ Presently, the magnitude of this total energy savings cannot be fully calculated, though sufficient information exists to compute a proxy to support near-term programs.

  - ✓ The state's current energy programs (codes and standards, incentives, and rebates) focus on energy saved at a single location from increasing water and process heating efficiency – not on energy that can be saved from reductions in water use. Not including cold water savings misses significant energy savings opportunities upstream in the water use cycle.

  - ✓ There are significant differences in the energy intensity of the water use cycle between Northern and Southern California because of differences in the energy intensity of water supply portfolios that are heavily dependent on imported resources.

- ✓ Options for new water resources in the future are limited. The least energy intensive option for future supplies is water use efficiency. The most energy intensive option is ocean water desalination.

- ✓ Water that is not consumed generally becomes available to offset highest marginal cost supplies.

- Modifications to the operations or design of the water system infrastructure present opportunities to reduce water system peak electric demand.

  - ✓ Some existing surface storage facilities can be modified to maximize generation opportunities and increase operational (peaking, load following) flexibility.

  - ✓ Many existing and most new water and wastewater treatment plants can be designed to detain water for treatment during off-peak hours.

  - ✓ Increased conjunctive use programs may allow for greater ability to shift energy demand seasonally.

- Currently, most water and energy systems are internally optimized on a single utility basis. Systems are rarely optimized in coordination with other systems (water, wastewater, electric and natural gas) or with their customers, missing opportunities to reduce total energy consumption, shift loads off-peak, or maximize energy generation.

- Opportunities within a utility system to develop additional generation resources (in-conduit hydroelectric generation, biogas combustion, and other renewable development) exist. However, significant barriers frustrate development of these resources.

- Energy demand in the water sector will likely increase over time due to a number of factors, including population and urban load growth, increased water and wastewater treatment because of more stringent water quality regulations to protect water quality, and market, economic, regulatory, and legislative changes.

- Several actions can be taken now to significantly reduce energy demand throughout the water use cycle and slow its future growth. This is particularly true in areas, like Southern California, which have tight energy supplies and constrained transmission systems.

The state's water and energy utilities separately seek to optimize their respective water and energy resources within their own portfolios. There are strong similarities between their IRP goals, methods and techniques. However, in developing its water resource strategy, DWR did not synchronize its water resource planning goals and

objectives with those of the Energy Commission to assure, for example, that local energy supplies and infrastructure can support greater desalination production. Where seawater desalination plants may be planned at points downstream of electric transmission congestion zones, the energy solution may be to build new generation in combination with the desalination plant. Another solution may be joint water and energy investments in recycled water infrastructure processing that could displace the need to build desalination facilities in the first place. This is one example of the types of water and energy tradeoffs that should be examined.

The most significant finding of this paper is that the greatest potential for positively impacting the state's energy circumstance is beyond current water and energy best practices. The opportunity is fortuitous, and the need is great. To accomplish mutually beneficial results will require increased coordination between programs and agencies, as well as a more complete understanding of the needs of both systems and customers. At a minimum, the state's future water plans should be coordinated with the state's energy management plans to both identify and reconcile potential areas of conflict and take advantage of points of synergy. Optimizing the systems and operations of both water and energy utilities throughout the state on a holistic societal value basis will provide the greatest net benefits.

Staff Recommendations

Based on the findings in this analysis, staff recommends an action-oriented approach that is structured to attain near- and long-term results. This approach should include policy integration that seeks to optimize the mutual and synergistic benefits of the water and energy systems and resources. A key aspect of this approach is the development and implementation of a comprehensive, statewide water-energy program that integrates water and energy resource planning and management. The following essential elements have been identified for a successful program.

1. Save energy by saving water.
2. Reduce water system net power requirements.

Importantly, while this is a significant undertaking, near-term benefits could be attained while longer-term plans and studies begin at the same time.

Save energy by saving water

Even though water efficiency programs and conservation efforts exist in the state, there are many missed opportunities to save energy and manage load. These include energy savings throughout the water use cycle through water use efficiency; changes in systems and operations to reduce peak time-of-use and seasonal demands; and changes in water management to reduce use of the highest energy intensive supplies. This is particularly unfortunate in areas where energy resources

are tight or peak energy demand is a problem. In fact, since load growth is the primary stressor of both water and energy resources, those areas that are shortest in water supplies are also energy constrained, making it even more crucial that the state's water and energy resources be managed on an integrated basis.

Staff concludes that the state could achieve nearly all of its energy and demand reduction goals for the 2006-2008 program period by simply allowing energy utilities to realize the value of energy saved for each unit of water saved. In that manner, energy utilities can co-invest in water use reduction programs, supplementing water utilities' efforts to meet as much load growth as possible through water efficiency. Remarkably, staff's initial assessment indicates that this benefit could be attained at less than half the cost to electric ratepayers for traditional energy efficiency measures. Staff should work with the CPUC and the energy and water utilities to evaluate the achievable savings and implementation strategies.

Staff therefore recommends that the state pursue policy options that achieve greater energy efficiency and saving through a more aggressive and comprehensive statewide water efficiency program. This program should target both site-specific efficiencies and actions that will result in net system energy savings. These actions could be a key part of the utility energy efficiency portfolios that accomplish savings needed to meet the CPUC's goals. Key elements of such a program include:

- Allowing energy utilities to count energy savings related not only to those achieved on site, but, where appropriate, those that can be identified throughout applicable portions of the water use cycle.

- Working with the Task Force, CPUC, DWR, and other stakeholders, refine data related to energy use and generation associated with the various parts of the water use cycle for use in accounting for the net energy impacts of this system and in calculating the effects of various programs designed to attain synergistic benefits.

- Target end user water efficiency measures that result in net energy savings – both on premises and in the water use cycle. For example, in addition to programs that save hot water, include programs that seek to maximize cold water savings in homes and businesses and count the net energy benefits attributable to a unit of avoided water consumption embedded in the entire water use cycle.

- Establish a collaborative with DWR, the CPUC, and the Energy Commission to achieve the state's least energy resource intensive water future by 2030. Align programs and policies to complement one another and remove barriers to mutually beneficial results.

- Invest in research that develops more water and energy efficient appliances, processes, designs, demand side management methods and technologies, and treatment systems.

- Establish a water resource loading order that incorporates the societal value of an avoided unit of water consumption that mirrors the preferred energy resource loading order in the *2005 Energy Report* and the Joint Agency *Energy Action Plan*.

- Establish a public goods charge equivalent for public purpose water conservation and efficiency programs that attain targeted net energy benefits.

- Require the state's energy and water planners to collaborate on plans and strategies to reduce net water sector energy consumption while meeting projected water and energy load growth with environmentally preferred resources and strategies.

- Commit public goods charge funds for expanded water efficiency programs and innovative technology development to reduce the net energy demand of the water use cycle in current 2006-2008 IOU energy efficiency portfolios.

Reduce water system net power requirements

The state should adopt a comprehensive policy to facilitate water and wastewater utility energy self-sufficiency by reducing water system net power requirements. This policy should include reducing operational energy requirements, shifting loads off-peak, and increasing energy generation from water- and wastewater-related resources and renewable opportunities. Implementing this policy is consistent with the objectives of the *2005 Energy Report* and the *Energy Action Plan* loading order and helps achieve the state's RPS goals.

- Develop cost-effective, environmentally preferred in-conduit, biogas and other renewable options for water and wastewater systems. To accomplish this, the Energy Commission should facilitate greater participation of water utilities in its loan and rebate programs by targeting planned retrofits at existing facilities and providing design assistance for planned facilities.

- Remove barriers to energy self-sufficiency by allowing water and wastewater utilities to self-generate power and provide this power to themselves anywhere on their systems; expedite and reduce costs of interconnections; eliminate economic penalties such as prohibitive standby charges; and remove caps on size of facilities eligible for net metering.

- Identify and implement retrofits in the water system that attain energy benefits, including but not limited to treatment system upgrades, turbine and pump replacements, and delivery system modifications.

- Require water and wastewater utilities to assess the energy impacts attributable to new or changed infrastructure and operations and evaluate feasible alternatives to reduce overall energy demand associated with these decisions.

- Provide incentives for incremental and/or joint infrastructure improvements that reduce total and peak energy requirements for water and wastewater conveyance and treatment.

- Facilitate collaboration among water and energy utilities and other local and state entities for the joint development of resources and infrastructure to further leverage benefits of their combined assets.

- Provide incentives for water, wastewater and energy utilities to optimize their joint resources beyond traditional discrete single utility service boundaries - water, wastewater, electricity, and natural gas.

In developing this report, Energy Commission staff established the Water Energy Relationship Working Group, which helped identify issues, evaluate possible resolution of those issues, and provide input on future policy options. This group demonstrated the need for the committed involvement of key stakeholders and an ongoing dialogue about the water-energy relationship. This cooperation and communication are vital to achieving the mutually synergistic benefits of water and energy systems.

Recommended Joint Actions

The Energy Commission, the DWR, the CPUC, the Air Resources Board, the State Water Resources Control Board, and the California Department of Health Services, should:

- Establish a valuation methodology for the water use cycle that accounts for embedded energy and externalities. This methodology is needed to capture these diversities in a manner that would assist planners in prioritizing their investments.

  - ✓ Incorporate a societal valuation approach in both water and energy utilities' resource pricing methodologies, water and energy efficiency program portfolios, and investment criteria.

  - ✓ To facilitate early results, establish a proxy for the societal value while a detailed methodology is being developed.

- Seek opportunities for joint investment that could produce incremental energy benefits but are not deemed cost-effective on a single-utility resource cost test.

- Leverage work already in progress by others, including the U.S. Department of Energy National Laboratories' Water-Energy Nexus Program, Pacific Institute, California Urban Water Conservation Council, and the Irrigation Training and Research Center. Work closely with these (and other) entities to:

  - ✓ Inventory, characterize, and measure California's water and energy interdependencies.

  - ✓ Develop pilot programs to test tools and methodologies for evaluating tradeoffs among these interdependencies.

  - ✓ Develop analytical models and tools for policymakers, regulators, utilities and other key stakeholders to use in developing cost-effective joint water and energy programs.

  - ✓ Research opportunities and technologies that improve the energy performance of the water use cycle and increase the generation capabilities of the water system.

Conclusion

While all of the nuances are not yet understood, it is clear that significant energy benefits are attainable through water use-efficiency and through increased energy efficiency in the water use-cycle. It is also clear that not nearly enough has been done to make sure that California's water supply strategies are synchronized with its energy strategies. Nor has enough been done to forge partnerships between the water and energy sectors and leverage the natural synergies of their joint resources and assets for the benefit of all Californians.

The state has the timely opportunity to reap near-term energy savings benefits by helping California's agricultural industry and water and wastewater utilities become more energy efficient. The CPUC could direct IOUs to invest current PGC funds for 2006-2008 energy efficiency programs in existing water infrastructure to improve operations, switch operations off-peak, and partially fund retrofits of equipment such as pumps and treatment equipment. These funds could also be used in conjunction with water conservation dollars to leverage greater water end use efficiency to realize net energy savings in the water use cycle. In addition, near-term actions could include minor adjustments to existing policies, programs, and market rules, to facilitate renewable and distributed generation development at water and wastewater facilities as well as agricultural resources to convert them from high energy users to net renewable energy producers.

For the long-term, California's water and energy policymakers need to commit today to joint planning and management of these critical resources. Conflicting policies and objectives need to be identified and conflicts resolved. Water resource plans need to include an accounting of energy impacts and evaluate alternatives to decrease

overall energy demand of water systems. The state's energy resource portfolio needs to consider and facilitate the development of all cost-effective and environmentally preferred water system related options. Water and energy agencies and utilities need to work together to identify mutually beneficial research and develop opportunities that the state can pursue to improve both systems, followed with market transformation strategies to accelerate adoption of resource efficient behavior. To achieve mutually synergistic benefits in the water and energy sector, policymakers, agencies, and utilities will need to work together and make long-term commitments of funds and programs.

APPENDICES

APPENDIX A: EXISTING ORGANIZATIONS, PROGRAMS, AND RESEARCH

The California Water Plan

The Department of Water Resources (DWR) is responsible for updating the *California Water Plan (Plan)*, which provides a framework for water managers, legislators, and the public to consider options and make decisions regarding California's water future. The *Plan*, which is updated every five years, presents basic data and information on California's water resources, including water supply evaluations and assessments of agricultural, urban, and environmental water uses to quantify the gap between water supplies and uses. The *Plan* also identifies and evaluates existing and proposed statewide demand management and water supply augmentation programs and projects to address the state's water needs. Often referred to as Bulletin 160, the most recent version is scheduled to be published in late 2005.

DWR is also responsible for managing the State Water Project, including the California Aqueduct, and managing the contracts for electricity created following the 2000-2001 energy crisis. The department also provides dam safety and flood control services, assists local water districts in water management, conservation, recycling and desalination activities, and promotes recreational opportunities.

Energy Use in the Water Cycle

Energy is used in every phase of water use within the state, from extraction through conveyance, treatment, use, and disposal. The Energy Commission has funded several projects to define this interaction between water and energy.

> **Electricity and Water Flows with California**
> The purpose of this project, conducted by the University of California, Santa Barbara and the Pacific Institute, is to identify the flows of both water and energy within California. This includes water for electricity generation (hydropower) and all of the electricity used for water – from initial diversion or extraction through conveyance, treatment, use, and disposal. This project will increase understanding of the electricity demand for different water uses within the residential, commercial, and industrial sectors. It will also further understanding of the energy intensity of the water cycle. The results of this study will help focus future water conservation programs where they will make the greatest impact on energy (PIER Environmental[64]).

[64] The names in parentheses at the end of the paragraphs identify the group within the Energy Commission that is responsible for the activity described in the paragraph.

Groundwater and Surface Water Management and Electricity Demand
Conjunctive use of surface and groundwater supplies is increasingly relied upon as a water management tool. Concern about a significant increase in conjunctive use and its associated electricity demand, particularly under drought conditions, is a major concern. Conducted by Lawrence Berkeley National Laboratory (LBNL), the aim of this project is to see how surface and groundwater supplies will be managed under different climatic conditions, and what the consequences would be for electricity demand and prices. It is important to consider not only the likely impact of new conjunctive use programs on regional electricity demands, but also how reservoir management will affect water supply for agriculture and municipal uses and electricity generation and demand. (PIER Environmental).

The U.S. Department of Energy's Energy-Water Nexus Team

In partial response to an identified gap in federal jurisdiction at the nexus of energy and water, the Energy Policy Act of 2003[65] directed the U.S. DOE to:

- Assess future water needs for energy, future energy for water purification and treatment, use of impaired water by energy, and technology for water use efficiency.

- Develop a program plan that incorporates scientific and technology requirements, decision tools, demonstration projects, and information transfer.

Eleven national laboratories and EPRI came together to form the federal Energy-Water Nexus Team (Team), which is charged with developing technology products that will help increase the nation's energy security. The scope of the Team's investigations is very broad:

- Energy versus water tradeoffs in optimizing hydropower and the implications of those tradeoffs on energy supply risk.

- Energy usage by water-related systems and processes (including municipal water, wastewater, and industry).

- Water used to produce energy, such as hydropower and water for cooling.

[65] Section 961, Subtitle (f) *Water and Energy Sustainability Program*.

- Development of tools, including benchmarking, and opportunities to improve efficiency both through more efficient energy consumption and redesigning processes, systems, and operations.

- Financial and economic analyses of markets and participants, including impacts on equipment manufacturers and utilities.

- Environmental impacts, including the economic impacts of hydrology and climate factors, relationships, impacts, and interdependencies.

Presently, the Team is undertaking a road-mapping process for the US DOE, viewed primarily from the perspective of water used for energy and energy used for water - particularly with respect to the research and development of new technologies to improve water and/or energy use and efficiency.

The Ernest Orlando Lawrence Berkeley National Laboratory and the Lawrence Livermore National Laboratory are participating in the Energy Commission's Water Energy Relationship Working Group and can help merge efforts undertaken by the state and the federal government.

The ***2005 Energy Policy Act*** (EPAct) expanded the scope of US DOE's studies on the water-energy nexus.

Water and Wastewater Facilities

Energy consumption is a significant cost component of providing water and wastewater services to the public. The Energy Commission is dedicated to providing resources to help water professionals reduce these costs through implementation of energy efficiency measures at their facilities.

AB 970 – Peak Load Reduction at Water and Wastewater Facilities
At the peak of the 2000-2001 energy crisis, AB 970 provided $4.5 million in grant funding to reduce 52.1 MW of peak electrical load at water and wastewater facilities in four categories: curtailment, efficiency, generation, and load shifting. The grants ranged from $9,000 to $486,000, with an average amount of roughly $110,000 per project, at a rate of $300 per peak kW reduction. This program has been completed (Energy Efficiency Division).

SB 5X – Water Agency Generation Retrofit Program
The program started in May 2001 and was completed in December 2003. Projects were funded in two categories - distributed generation and energy efficiency - with a total on-peak load reduction capacity of 17.7 MW. Of this capacity, distributed generation retrofits provided up to 9.2 MW of on-peak load reduction, while energy efficiency projects provided up to 8.5 MW of load reduction. Twenty-eight qualified applicants received $4.35 million from this

program. The program paid distributed generation participants an average of $259/kW for projects with a combined construction cost of $7,205,488. Energy efficiency participants received an average of $230/kW for their projects, which cost $6,598,108 to install. Overall, the program averaged $245/kW of electrical load reduction (Energy Efficiency Division).

Flex-Your-Power's Water and Wastewater Guide: Reduce Energy Use in Water and Wastewater Facilities Through Conservation and Efficiency Measures

In response to the 2000-2001 energy crisis, the state's Flex-Your-Power program worked with hundreds of California water and wastewater agencies to develop measures to reduce energy consumption by 15 percent within their systems and facilities, for the purpose of both reducing power costs and alleviating the risk of rotating outages. A four-step process was developed to increase energy self-sufficiency through a combination of on-site power production, total energy consumption reductions through energy efficiency measures and retrofits, and peak shifting to partial- and off-peak periods wherever possible.

Energy Partnership Program

This program provides customized technical assistance to water and wastewater facilities to identify energy efficiency projects, project costs, and associated savings. Consultants are paid up to $20,000 for a detailed study of the facilities. Approximately $260,000 have been paid so far to consultants for feasibility studies, comprehensive energy audits, reviews of energy projects proposals, identifying cost-effective energy-saving measures, review of specifications for energy efficient equipment, and assistance in selecting contractors and design professionals for the water and wastewater facilities that have participated in this program (Energy Efficiency Division).

Energy Efficiency Financing Program

Energy Efficiency Financing Program: The Energy Commission provides low-interest rate loans to fund up to 100 percent of the cost of energy efficiency and self-generation projects. Loans are provided on a first-come, first-served basis. Eligible projects must have an average simple payback of less than 9.8 years. If projects have a greater simple payback, the Energy Commission can provide a loan equal to 9.8 times the annual energy cost savings. Eligible projects include pumps and motors, variable frequency drives, lighting, building insulation, HVAC modifications, automated energy management systems, automated energy management controls, energy generation, streetlights and light emitting diode (LED) signals. The Energy Commission has provided more than $11.2 million in loans for projects associated with both improving the energy efficiency of water and wastewater facilities and reducing the energy costs of these facilities. These projects have saved public facilities about $1.9 million annually in lower energy bills. This is

equivalent to saving 23 million kWh annually, with billing demand savings of about 2.3 MW (Energy Efficiency Division).

Development of a Water and Wastewater Industry Energy Efficiency Roadmap

The Energy Commission collaborated with the American Water Works Association Research Foundation (AwwaRF) {Note: Thought I'd flag this since lower-case letters are so rare in acronyms – is this correct?] to develop a roadmap to fund the highest priority research and development energy needs of California's water and wastewater utilities. To achieve this, the Commission and AwwaRF in February 2003 conducted a workshop that was attended by water experts from water and wastewater facilities, electric utilities, academia, researchers, and consultants. More than 44 projects in eight research areas were developed and ranked according to their savings potential (in either kilowatts or dollars), likelihood of success, and timeliness. The Energy Commission and AwwaRF committed to more than $2 million in funding for the five highest-ranked projects. These projects are:

> **Development of a Utility Energy Index to Assist in Benchmarking of Energy Management for Water and Wastewater Utilities**
> The objective of this project is to produce industrywide energy performance metrics to describe the performance of water and wastewater utilities that will subsequently be incorporated within a comparison framework (benchmarking tool) to facilitate internal and external comparisons within and between utilities. The approach will be similar to the US EPA's **Energy Star®** program, which makes energy performance comparisons in commercial buildings (PIER Industry, Agriculture and Water).
>
> **Zero Liquid Discharge and Volume Minimization for Inland Desalination**
> This project is discussed in the section on desalination (PIER Industry, Agriculture and Water).
>
> **Assessing Risks and Benefits of Drinking Water Utility Energy Management Practices**
> The project will develop a decision framework based on risk management principles for water utilities implementing energy management strategies. The risks and benefits of a broad array of both supply-side and demand-side energy management options will be assessed. The decision framework will provide a management tool for water utilities to mitigate possible downsides to water quality and reliability when implementing energy management practices or technologies (PIER Industry, Agriculture and Water).

Water Consumption Forecasting to Improve Energy Efficiency of Pumping Operations

The purpose of this project is to provide the best options for short-term water consumption forecasting for water utilities. Short-term consumption forecasting (SCTF) is required for water utilities to proactively optimize both their pumping and treatment operations and water supply and treatment costs while maintaining a reliable and high-quality product for their customers. The project will provide information on various techniques, performance data, benchmarks, selection criteria, and functional requirements to help utilities evaluate and select the best forecasting techniques. The project will examine different forecasting methods currently used at public utilities. These forecasting methods will be tested at utilities that are not currently forecasting their water consumption, and the results will be documented. The SCTF performance data will be analyzed for all seasons of the year to provide peak, off-peak, and average-day consumption data (PIER Industry, Agriculture and Water).

Evaluation of the Dynamic Energy Consumption of Advanced Water and Wastewater Treatment Technologies

The objectives of this project are to quantify the actual and theoretical energy consumption of selected water and wastewater advanced treatment unit operations, evaluate the factors that affect energy consumption, and identify energy optimization opportunities while still maintaining treatment performance (PIER Industry, Agriculture and Water).

Future Projects in Collaboration with AwwaRF

Five more projects from the roadmap are being considered for future funding by the Energy Commission and AwwaRF.

1. Review of international desalination research. The product would be a searchable CD ROM database similar to Desal Net, owned by AWWA (not AwwaRF). Desal Net is a searchable CD ROM database for the U.S.
2. Energy consumption of ultraviolet and chlorine/hypochlorite disinfection.
3. UV disinfection: Develop next generation of energy efficient UV disinfection systems for water and wastewater treatment.
4. Development of a guidance manual to design and operate desalination facilities for maximum energy efficiency.
5. Identification and evaluation of innovative water treatment processes.

Agricultural Water

Energy consumption is a significant cost component of providing water to the agricultural industry. State and IOU ratepayer funds, administered by the Energy Commission, CalPoly San Luis Obispo, and Fresno State University have delivered energy efficiency and water conservation programs aimed at conservation and peak load reduction in agriculture. Programs include:

SB 5X –Agricultural Peak Load Reduction Program

- The program started on June 1, 2001, and was completed on December 31, 2004. The program components related to electricity used for water purposes, include:
- 1. The development and implementation of a pump test and repair program to improve pumping plant efficiencies.
- 2. Funding projects with irrigation districts and large farming companies to participate in demand response and TOU schedules. Over 60 MW of on-peak load reduction was achieved. Thousands of pump tests were performed and many of the tested pumps were repaired to achieve even higher efficiencies (Nexant, M&V report for California Energy Commission Agricultural Peak Load Reduction Program, 2003). More than $7 million were dedicated to water-related energy projects.

CPUC- Public Goods Charge (PGC)-Third-Party Administrator for Pump Test and Repair Program

The program, administered by the Fresno State University Center for Irrigation Technology, delivers pump test services to customers in the PG&E and SDG&E service territories. The pump tests are conducted by private sector providers that have enhanced the quality and standards of properly conducted pump test results for several years. The program also provides pump repair incentive payments. The educational component is a valuable tool for communicating efficiency principles and water conservation practices to farmers. A $5 million annual appropriation from the CPUC has funded this effort to date.

Development of an Agricultural Water Energy Efficiency Roadmap

The Energy Commission's PIER Agricultural Program Technology Roadmap was accomplished in collaboration with CalPoly San Luis Obispo, Fresno State University, the University of California Cooperative Extension Program, industry associations, farmers, and irrigation district managers. The roadmap document calls for research and development efforts that improve irrigation efficiency, create flexible water delivery systems, and achieve peak load reduction. Possible research, development, and demonstration projects include reducing the total pressure required to operate drip irrigation technologies (including the filter system as well as the pipe and micro-sprayer

technologies), advancing the use of longer-lasting materials for pump components, and working with the State Water Project, the Central Valley Project, and the irrigation districts to increase the flexibility of water deliveries to farms. Additional information is available at: [http://energy.ca.gov/2005publications/CEC-400-2005-002/CEC-400-2005-002.PDF].

PIER Agriculture Energy End Use Efficiency

The purpose of this contract is to improve the energy efficiency in the transportation, delivery, and utilization of agricultural water provided by irrigation districts. Proposed outcomes include:

1. Documenting the implementation of new technologies.
2. Developing a simple procedure for tuning controller constants for automatic upstream control of canal check structures.
3. Developing new devices resistant to plugging or tangling moss for volumetric metering of delivered water - trash shedding propeller meters.
4. Testing and evaluating new electronic technologies for the volumetric metering of delivered water such as magnetic meters, ultrasonic meters (Doppler), vortex shedding meters, and ultrasonic flow-measurement meters.
5. Developing strategies for energy-efficient transition from low-pressure non-reinforced concrete pipe.
6. Verifying power quality measurement and conditioning methods.
7. Assessing use of variable frequency drives on agricultural pumps.

National Programs

Development of a National Water-Wastewater Industry Energy Roadmap
In order to bring together the energy efficiency and water/wastewater communities to define avenues for increasing energy efficiency in the water and wastewater sectors, the American Council for an Energy Efficient Economy (ACEEE) organized a national road mapping workshop to further explore and plan next steps for greater energy efficiency in the water/wastewater sectors. A workshop was held in Washington, D.C., in July 2004, and a final report is being refined for publication. The Energy Commission was a member of the advisory committee. The advisory committee defined the scope of this effort, developed a mission statement for the project, and established a set of goals. It also assisted ACEEE staff in identifying key issues relating to energy use in the water and wastewater industries. These issues formed the basis for design of a survey instrument that was used to collect impressions of key issues from a wider group of

stakeholders identified by the advisory committee. Based on this research and the goals of the workshop, ACEEE staff and the advisory committee developed an agenda that addressed key topics (Energy Efficiency Division).

National Municipal Water and Wastewater Facility Initiative
In 2002, the Consortium for Energy Efficiency (CEE) formed the Water and Wastewater Exploratory Committee to:

- Serve as a platform for members to exchange program information and resources.
- Better understand the water and wastewater industry - its structure, energy use, decision-making, and regulatory environment.
- Begin outreach efforts to the water and wastewater industry and other industry stakeholders.
- Explore the merits of a national program initiative to improve the effectiveness of local programs serving this sector. This initiative is intended to maintain a sustained focus on facility energy-efficiency at the national and local levels by increasing demand for energy-efficiency products and services within the municipal water and wastewater sector, and by transforming the delivery of products and services to the municipal water and wastewater sector by encouraging industry stakeholders to incorporate energy-efficiency as a standard business practice. The Energy Commission is a founding member of this initiative (Energy Efficiency Division).

US EPA's ENERGY STAR Water and Wastewater Facilities Initiative
ENERGY STAR is a voluntary program that helps organizations, businesses, and individuals protect the environment through superior energy performance. The ENERGY STAR Water and Wastewater Facilities Initiative helps improve energy performance by creating momentum for the continued improvement of energy efficiency by identifying and tackling barriers to energy efficiency in the water and wastewater industry, providing tools and resources to enhance energy performance, uncovering new energy-saving opportunities, and encouraging information-sharing on efficiency in the water and wastewater industry. The Energy Commission is one of the founding members of this initiative. The first Web conference on the Energy Star Water and Wastewater Facilities Initiative was on May 12, 2005 (Energy Efficiency Division).

Water Supply

Desalination

Desalination is one of the sources of new water identified by the Department of Water Resources in the ***2005 Water Plan Update***. It is also the most energy intensive of these new sources. There are several efforts underway to assist in the

development of low-cost, energy-efficient desalination technologies for various source waters using membrane and thermal processes.

Improving Energy Usage, Water Supply Reliability and Water Quality Using Advanced Water Treatment Processes

The Energy Commission and the Metropolitan Water District of Southern California are jointly funding the full-scale demonstration and refinement of newly developed electro-technologies for producing potable and non-potable water. These technologies remove salts and disinfect various source waters, including Colorado River water, brackish groundwater, municipal wastewater, and agricultural drainage water. There are 18 individual projects and eight research partners involved in this research program (PIER Industry, Agriculture and Water).

Zero Liquid Discharge (ZLD) Desalination of Inland Waters

At coastal facilities, concentrate is typically discharged to the ocean. This option is not available at inland facilities, and the need to protect surface water and groundwater sources may preclude disposal into the environment. The alternative is ZLD, in which the concentrate is further treated to produce desalinated water and essentially dry salts. In collaboration with AwwaRF, this research project will develop technologies that reduce the cost and energy consumption for inland desalination (PIER Industry, Agriculture and Water).

West Basin Municipal Water District – Demonstration of a Low Energy Sea Water Reverse Osmosis (SWRO) Desalination

Energy is the single largest cost component of operating seawater desalination systems. The purpose of this project is to demonstrate that SWRO desalination can be performed at 1.6 kWh/m^3 of permeate produced. The project will also establish the relationships between reverse osmosis recovery rate, membrane salt rejection, permeate quality, boron levels, feed pressure, and energy consumption. These relationships will help the SWRO desalination industry establish optimum recovery, flux, and salt rejection rates using today's best-available technologies. This research is being conducted by the West Basin Municipal Water District, in collaboration with the DWR, several local water agencies, and the industry, in collaboration with the Naval Facilities Engineering Service Center's Seawater Desalination Test Facility at Port Hueneme, California (PIER Industry, Agriculture and Water).

California Desalination Task Force

In September 2002, AB 2717 (Hertzberg) was signed into law, directing the DWR to convene a Desalination Task Force (Task Force) to "make recommendations related to potential opportunities for the use of seawater and brackish water desalination." The work of the Task Force and its subsequent findings and recommendations provided a useful background to DWR in developing Proposition 50 guidelines for funding desalination

projects and for estimating the future potential and prospects of desalination in the ***2005 California Water Plan Update***. The Energy Commission served as one of the four co-chairs of the Task Force along with California Coastal Commission, State Water Resources Control Board, and State Department of Health Services (Energy Efficiency Division).

Salton Sea Desalination Demonstration Project Using Geothermal Heat
Energy Commission staff is serving on the advisory panel for U.S. Bureau of Reclamation's geothermal-driven vertical tube evaporation (VTE) desalination test project at the Salton Sea, to be conducted by Sephton Water Technology (SWT). The purpose of this project is to demonstrate the feasibility of controlling the salinity, nutrient, selenium, and other contaminant content of seawater by using geothermal waste steam to drive a VTE desalting system. The project satisfies one of the principal goals of the California Desalination Task Force, which is to identify potential opportunities for brackish water desalination, as well as the Energy Commission's need to improve the energy efficiency of water and wastewater treatment facilities in California. The project also addresses the problem of concentrate disposal. In this case, the plan calls for the concentrate to be pumped "down hole" to help recharge the geothermal aquifer, resulting in zero liquid discharge from the desalting plant (Energy Efficiency Division).

National Programs

Implementation of the U.S. Bureau of Reclamation's Desalination Roadmap
In 2001, Congress directed the Bureau of Reclamation to work with Sandia National Laboratories (SNL) to develop a desalination technology research plan for the United States. With the help of a multidisciplinary committee of representatives from academia and the public, private, and non-profit sectors***, The Desalination and Water Purification Technology Roadmap: A Report of the Executive Committee (Roadmap)*** was published in January 2003. The ***Roadmap*** presents a summary of water supply challenges facing our nation through 2020 and suggests areas of research that could lead to technological solutions for these challenges. The ***Roadmap*** may be used as a planning tool to facilitate science and technology investment decisions or as a management tool to help coordinate research efforts. To develop a mechanism to implement the recommendations of the Desalination Roadmap, the Joint Water Reuse and Desalination Task Force (JWR&DTF) was formed and is conducting workshops to establish a desalination research funding process. The Energy Commission was a member of the JWR&DTF planning committee that organized these workshops, and will participate in these workshops in the near future (Energy Efficiency Division).

Working Group on Concentrate Management Guidelines for Desalination and Water Reuse
Both the U.S. Bureau of Reclamation's ***Desalination and Water Purification Technology Roadmap,*** published in 2003*,* and the California Desalination Task Force identified concentrate management as a major area where research is needed to create next-generation desalination technologies. To help address the identified technical and environmental concerns associated with desalination and water reuse concentrate, Sandia National Laboratories initiated an effort, in cooperation with the Bureau of Reclamation, the American Water Works Association, the American Society of Civil Engineers, and the Water Reuse Foundation, to jointly develop guidelines for concentrate management. Energy Commission staff actively participate in the Concentrate Management Working Group, which is working on these guidelines (Energy Efficiency Division).

National Salinity Management Conference
This high-profile annual national conference is jointly sponsored by Multi-State Salinity Coalition, the US Desalination Coalition, the Northern California Salinity Coalition, the Water Reuse Association, the Southern California Salinity Coalition, and others in conjunction with the Nevada Water Reuse Association. It includes invaluable presentations, industry tours, and roundtable discussions on technical, policy, and program issues concerning energy issues in desalination. Energy Commission staff are regular members of the planning committee for this conference (Energy Efficiency Division).

Water Treatment

Developing and Validating an Energy Efficient Arsenic Removal Process
The current EPA standard for arsenic, a naturally occurring contaminant in groundwater, is 50 parts per billion (ppb). Effective January 2006, federal standard for arsenic in drinking water will be lowered to 10 ppb. The new arsenic standard will leave many public drinking water supply systems out of compliance, including several hundred systems in California. California has set a long-term public health goal for arsenic in drinking water at 4 parts per trillion (ppt) -- 2,500 times lower than the new federal standard of 10 ppb.

To attain this standard, the water systems in California will have to first meet the EPA standards in a cost-effective manner. Currently, the average cost of lowering arsenic from 50 ppb to 10 ppb from drinking water is in the range of $58 to $237 per household per year. Lawrence Berkeley National Laboratory is conducting research on an innovative medium, which, if successful, will lower the arsenic removal cost to $1 per household per year and have little or no incremental energy costs over current practices (PIER Industry, Agriculture and Water).

Wastewater Treatment

Development and Demonstration of a Digital System for Control and Mentoring of Oxygen Transfer Efficiency (OTE) Measurements
The majority of wastewater treatment plants nationwide uses an activated sludge secondary treatment process. Blowing air into the activated sludge aeration tanks accounts for 50 to 80 percent of a wastewater treatment plant's entire energy consumption. Over time, the diffusers through which this air blows become fouled by bacterial slime growth and scale buildup from hard water. One of the challenges of the wastewater industry is to monitor in real time the performance of wastewater treatment and how well aeration systems function.

Aeration system performance can be correlated with power consumption and calculated from material balances, but these results are not obtained in real time and can take weeks or months to obtain. A much better method is to measure OTE directly, using data collected from an instrument that measures oxygen in the gas released from the surface of the aeration basin. Currently, commercially available OTE instruments are large, heavy, and fragile, and require a crew of several people to operate. The purpose of this project is to design and demonstrate a new digital, fully-automated off-gas testing technology for purposes of evaluating and optimizing oxygen transfer efficiency, which would reduce energy demand (PIER Industry, Agriculture and Water).

Water-Related End Uses

Several projects underway are looking at ways to reduce the energy consumption of water-related end uses. Other efforts are focusing on increasing water use efficiency.

Waste Not, Want Not: The Potential for Urban Water Conservation in California
In 2003, the Pacific Institute published a report that quantified the unrealized potential for cost-effective water conservation in California. The report estimated that nearly 30 percent of potable water consumed in California – as much as 2 million acre-feet per year – could be cost-effectively conserved. In the context of the Pacific Institute's report, cost-effective is defined as "… the point where the marginal cost of the efficiency improvements is less than or equal to the marginal cost of developing new supplies."

Energy Down the Drain -The Hidden Costs of California's Water Supply
In the western United States there is a close connection between water and power resources. Water utilities use large amounts of energy to treat and deliver water, and even after utilities deliver water, consumers use even more

energy to heat, cool, and use it. This August 2004 report from the National Resources Defense Council (NRDC) and the Pacific Institute shows how water planners in California have largely failed to consider the energy implications of their decisions, and suggests a model for policymakers to calculate the amount of energy consumed during water use. Integrating energy use into water planning can save money, reduce waste, protect the environment, and strengthen the economy.

Water for Growth: California's New Frontier
According to the Public Policy Institute of California, which issued this report in July 2005, California's population grew by over 10 million between 1980 and 2000. It is expected to increase by another 14 million by 2030, reaching a total of 48 million by that date. One of the most serious concerns of policymakers is whether the state will be able to supply enough water to support a population of this size. If per capita urban water use remains at its 2000 levels of 232 gallons per person per day, California will face an expansion of water demand of 40 percent, or 3.6 million acre-feet, by 2030. Policymakers and water planners have begun to consider several ways to bring supply and demand into balance over the years ahead. Options include expansion of nontraditional sources of supply (for example, underground storage, recycling, and desalination), reallocation through water marketing and conservation incentives and regulations.

California Water 2030: An Efficient Future
On September 13, 2005, the Pacific Institute released its newest report on the potential for saving water in California by 20 percent over the next 25 years while satisfying a growing population, maintaining a healthy agricultural sector, and supporting a vibrant economy. The report discusses how smart technology, strong management, and appropriate rates and incentives can allow the state to meet its needs well into the future, using less water.

The Irrigation Training and Research Center (ITRC)
The Irrigation Training and Research Center (ITRC) was established in 1989 at California Polytechnic State University, San Luis Obispo, as a center of excellence built upon a history of contributions to agriculture. The ITRC has a number of ongoing programs to develop and promulgate irrigation best practices in California. While ITRC's research focuses on irrigation for agriculture, the tools, technologies, and techniques are often applicable to landscape irrigation as well (PIER Industry, Agriculture and Water).

California Urban Water Conservation Council (CUWCC)
The CUWCC is a non-profit organization created to increase efficient water use statewide through partnerships among urban water agencies, public interest organizations, and private entities. The Council's goal is to integrate urban water conservation BMPs into the planning and management of California's water resources. Presently, more than 300 urban water agencies

and environmental groups are signatories to a historic memorandum of understanding pledging to develop and implement 14 comprehensive water conservation BMPs. To the extent that the state adopts a policy allowing energy utilities to invest in water savings for their energy and environmental benefits, CUWCC's goals and activities are certainly in direct alignment.

Residential Hot Water Distribution System Research Project
The purpose of this project was to conduct a scoping study to establish the first-order estimate for the water and energy wasted in hot water distribution systems in California and the United States. This study found that the losses in residential hot water distribution systems total more than $1 billion per year in California and $10 billion per year in the United States, including the cost of energy, water, and wastewater treatment. A roadmap to identify future activities was part of the original project but has not been completed (PIER Buildings).

Testing of Hot Water Distribution Systems
The purpose of this project was to systematically test the performance of hot water distribution systems. Field work assessing the types of distribution systems in current construction practice was combined with laboratory testing. Test procedures were developed and used on ½- and ¾-inch copper piping and ¾-inch PEX-Aluminum-PEX piping. Tests were conducted in air on both uninsulated and insulated pipe. The results of this project will be combined with additional testing to support the 2008 Title 24 Residential Building Energy Efficiency Standards proceeding (PIER Buildings).

Water Heating R&D for the 2008 Residential Building Energy Efficiency Standards
This research will provide hot water distribution system data, analysis, and recommendations to the 2008 Title 24 Residential Building Energy Efficiency Standards proceedings. Specific efforts will inform the building standards proceeding in the areas of multi-family water heating, hot water pipe losses, single family water heating construction practices, and hot water distribution system modeling. This project will also study California housing's current hot water performance issues and cost-effective retrofit opportunities, and identify future research priorities for hot water distribution systems (PIER Buildings).

Super Efficient Gas Water Heating Appliance Initiative
This research will develop the foundation for a multi-year initiative to determine the best approach for achieving a 30 percent efficiency improvement in gas water heaters. Technical and market analysis will be conducted, along with stakeholder involvement, to implement a product development competition that develops and tests prototypes for safe, reliable, and cost-effective replacements for natural gas water heaters (PIER Buildings).

Market and Technical Considerations for a Next Generation Instantaneous Water Heater

Gas-fired instantaneous water heaters are highly efficient and can play an important role in reducing energy consumption. The barriers to the current generation of instantaneous water heaters include higher initial cost, installation cost adders, water waste associated with start-up, the inability to adjust to low flow rates or relatively warm incoming cold water, and the inability to meet large household or simultaneous demands. The goal of this research is to determine if current state-of-the art instantaneous water heaters can meet both current and projected California domestic hot water needs and to identify technology(ies) that can be incorporated into instantaneous water heaters to overcome current market and technical barriers (PIER Buildings).

Energy Efficiency Potential of Gas-Fired Commercial Water Heating Equipment

The goal of this research is to establish representative gas loads for both the installed base and higher-efficiency hot water systems in commercial kitchens, based upon a review of current literature monitoring data for three commercial food service sites (a quick-service, full-service, and institutional facility). This field experience will form the basis for a design guide for hot water systems in commercial food service (PIER Buildings).

Water for Electricity Generation

Water is used to generate electricity, both directly in hydropower plants and indirectly as part of cooling systems in thermal electric facilities. The Energy Commission has funded several projects to evaluate ways to reduce the effects of electricity generation on California's freshwater supplies and on aquatic species and habitats.

The Ecological Effects of Pulsed Flows from Hydropower Plants

The Center for Aquatic Biology at the University of California, Davis, is conducting research addressing the ecological effects of ramping and other pulsed flows from hydropower plants. These discharges are results of load following, sediment and vegetation management, and recreational requirements. Seven different projects are evaluating a wide range of issues, from the effects of these flows on invertebrates residing in stream and river bed sediment to the effects on the potentially threatened foothill yellow-legged frog. The purpose of this research is to provide information that will prompt regulatory decision making that would not otherwise be accomplished within the regulatory process. The information from this research will be used by regulators to establish information needs for impact assessment, set impact thresholds, and establish suitable mitigation measures. Research partners include the State Department of Water Resources, California Department of Fish & Game, PG&E, EBMUD, and NOAA Fisheries (PIER Environmental).

Development of Bioassessment Criteria for Hydropower Operation
The California Department of Fish and Game is conducting research to develop environmental indicators, using benthic macroinvertebrates, to assess and monitor the effects of hydropower operation on rivers and streams. The purpose of this project is to establish a low-cost assessment and monitoring tool that will provide a direct indication of ecosystem health, as opposed to relying upon indirect factors such as water temperature or flow. Research partners include the California Department of Fish and Game, California State Water Resources Control Board and California State University, Chico (PIER Environmental).

Integrated Forecast and Reservoir Management Project
Runoff and stream flow forecasting has historically relied upon limited hydrologic records. With the development and refinement of global circulation models and an improved understanding of climate conditions and their ramifications for California, future runoff probabilities can be more accurately predicted. Using these forecasts on an hourly to seasonal basis can result in better planning and optimization of California's water resources. The Energy Commission is funding a demonstration of this approach for four Northern California reservoirs: Shasta, Trinity, Oroville, and Folsom. This effort uses global circulation model scenarios, downscaled to hydrologic models, that encompass the catchments of each of these reservoirs, as well as the entire Sacramento River. This information is used to create probabilistic forecasts on an hourly to month-long basis. Since these major reservoirs are all multi-purpose, the project includes the development of decision support models that will allow reservoir operators to make better decisions about the balance between flood control, water supply, hydropower generation, and instream flow requirements. Based upon a retrospective analysis of Folsom Reservoir using this methodology, the researchers showed that there could be a15 percent increase in hydropower generation. Research partners include the National Oceanic and Atmospheric Administration, CalFed, the Department of Water Resources, Sacramento Area Flood Control District, the U.S. Bureau of Reclamation and the Army Corps of Engineers (PIER Environmental).

Development of Seasonal Forecast of Hydropower Generation
Scripps Institute is developing seasonal forecasts of hydropower production in the Pacific Northwest and California. Since the amount of hydropower production in these two regions has a significant effect on the cost and availability of electricity within California, providing forecasts on a seasonal basis will improve energy planning, especially natural gas demand. Another aspect of this project is to develop seasonal temperature predictions for California based upon global circulation model simulations. This information will allow planners to predict whether an upcoming summer will be exceptionally severe and plan accordingly. Research Partners include the Western Electricity Coordinating Council (WECC), Pacific Northwest National Laboratory and the University of Washington (PIER Environmental).

Advanced Cooling Strategies and Technologies
This program is being managed by EPRI and addresses approaches for reducing freshwater consumption in the thermal generating sector. Specifically, the program addresses both the barriers to wider adoption of water conserving cooling technologies and alternative cooling technologies. These approaches, such as the use of air-cooled condensers, can substantially reduce the amount of water used within a power plant. There are, however, economic and performance issues to overcome before industry will adopt these approaches. Research partners include NETL, Reliant, AES and Crockett Cogeneration (PIER Environmental).

Ecological Effects of Cooling Water Intake Structures
Within California, a significant portion of in-state thermal electric generation is from coastal power plants that use once-through cooling, which uses millions of gallons of water per day. The intake of these vast amounts of cooling water, which is not evaporated, means that millions of the eggs, larvae, and other early life stages of fish, clams, and other aquatic species are destroyed by the heat transferred to the cooling water. The ecological effects of this once-through cooling are not known. In addition, there is a need to develop new assessment techniques and establish the suitability of innovative technology to reduce this impact. The Moss Landing Marine Laboratory, a part of California State University, San Jose, is managing the research program on this topic. Research partners include the California Costal Commission, the California Department of Fish and Game, NOAA Fisheries and the University of California, Santa Cruz (PIER Environmental).

RPS-Eligible Small Hydropower Resource Assessment
The purpose of this project is to assess the magnitude of in-conduit resources potentially available for greater small hydropower development in California. Specifically, the study focuses on irrigation and municipal water systems where no new appropriation or diversion is required, which retains RPS eligibility under the conditions of SB1078. This study does not cover new or incremental power at existing dams or other potential in-conduit resources such as industrial process water and municipal wastewater (PIER Renewables).

Use of a Down-Hole Pump as a Turbine-Generator
The purpose of this project is to demonstrate and assess the performance of a reverse operated down-hole pump commonly used in the oil and gas industry as a turbine-generator for power production. The unit will be demonstrated in a Northern California Power Agency injection well at the Geysers, where the feedstock will be treated wastewater used to replenish and extend the life of the region's underground steam fields. If successful, this would provide a means of partially offsetting the cost of pumping wastewater to the injection site (PIER Renewables and GRDA).

APPENDIX B: 2001 CALIFORNIA ENERGY CONSUMPTION BY END USE

2001 California Energy Consumption by End Use

Sector	Description	Electricity (GWh)	Percent Related to Water	Natural Gas (million therms)	Percent Related to Water	Adjusted Electricity (GWh)	Adjusted Natural Gas (million therms)
AG & WP	Domestic Water Pumping	11,953	1.00	19	1.00	11,953	19
AG & WP	Crops	3,284	1.00	103	0.05	3,284	5
AG & WP	Irrigation Water Pumping	2,269	1.00	5	1.00	2,269	5
AG & WP	Livestock	1,216	0.50	15	0.50	608	8
RESIDENTIAL	Clothes Drying	5,769	1.00	145	1.00	5,769	145
RESIDENTIAL	Water Heating	2,352	1.00	1,079	1.00	2,352	1,079
RESIDENTIAL	Indirect Hot Water Heating for Clothes Washing	1,053	1.00	486	1.00	1,053	486
RESIDENTIAL	Washing Machine	726	1.00	0		726	0
RESIDENTIAL	Indirect Hot Water Heating for Dish Washing	686	1.00	316	1.00	686	316
COMMERCIAL	Water Heating	549	1.00	174	1.00	549	174
RESIDENTIAL	Evaporative Cooling	519	1.00	0		519	0
RESIDENTIAL	Solar Water Heating	18	1.00	7	1.00	18	7
COMMERCIAL	Cooling	12,916	0.50	66	0.50	6,458	33
MINING & CON	Oil and Gas Extraction	3,958	0.50	2,775	0.50	1,979	1,388
RESIDENTIAL	Dish Washing	2,008	0.50	0		1,004	0
INDUSTRY	Publishing and Broadcasting Industries	955	0.50	9		478	0
INDUSTRY	Printing and Related Support Activities	773	0.50	19		386	0
INDUSTRY	Nonmetallic Mineral Product Manufacturing	710	0.50	116		355	0
TCU	National Security and International Affairs	2,649	0.20	60	0.30	530	18
RESIDENTIAL	Residential Miscellaneous	24,419	0.05	168	0.05	1,221	8
COMMERCIAL	Commercial Miscellaneous	19,156	0.05	722	0.05	958	36
INDUSTRY	Petroleum Refining and Related Industries	7,194	0.05	1,464	0.05	360	73
COMMERCIAL	Refrigeration	6,771	0.05	5	0.05	339	0
INDUSTRY	Food Manufacturing, Beverage and Tobacco	4,939	0.05	390	0.50	247	195
INDUSTRY	Chemicals	3,674	0.05	226	0.05	184	11
RESIDENTIAL	Cooking	3,595	0.05	286	0.05	180	14
INDUSTRY	Electronic Components	3,261	0.05	39		163	0
INDUSTRY	Computer and Electronic Product Manufacturing	2,988	0.05	37	0.05	149	2
INDUSTRY	Plastics and Rubber Products Manufacturing	2,886	0.05	40		144	0
TCU	Telephone	2,289	0.05	3		114	0
INDUSTRY	Fabricated Metals	2,045	0.05	122	0.05	102	6
INDUSTRY	Transportation Equipment	1,960	0.05	84		98	0
INDUSTRY	Machinery Manufacturing	1,777	0.05	24		89	0
INDUSTRY	Miscellaneous Assembly Industry	1,300	0.05	14		65	0
INDUSTRY	Sugar and Canned, Dried, and Frozen Food	1,283	0.05	299	0.50	64	149
MINING & CON	Construction	1,213	0.05	22	0.05	61	1
INDUSTRY	Primary Metals	1,192	0.05	133	0.05	60	7
INDUSTRY	Pulp, Paper, and Paperboard Mills	1,149	0.05	110	0.50	57	55
TCU	Electric and Gas Services, Steam Supply	1,006	0.05	25	0.05	50	1
INDUSTRY	Lumber	951	0.05	56		48	0
INDUSTRY	Paper Products; Excludes SIC 261,262,263,266	895	0.05	51		45	0
INDUSTRY	Furniture and Fixtures	793	0.05	9		40	0

Sector	Description	Electricity (GWh)	Percent Related to Water	Natural Gas (million therms)	Percent Related to Water	Adjusted Electricity (GWh)	Adjusted Natural Gas (million therms)
TCU	Airports, Flying Field and Airport Terminal Service	771	0.05	5	0.05	39	0
COMMERCIAL	Cooking	758	0.05	141	0.05	38	7
INDUSTRY	Electrical Equipment, Appliance, and Component Manufacturing	646	0.05	7		32	0
MINING & CON	Mining (except Oil and Gas)	615	0.05	58	0.05	31	3
INDUSTRY	Textile Products	397	0.05	8	0.05	20	0
INDUSTRY	Textiles	386	0.05	65	0.05	19	3
INDUSTRY	Textile Products	183	0.05	14	0.05	9	1
RESIDENTIAL	Pool Heating	60		100		0	0
RESIDENTIAL	Hot Tub Fuel	168		93		0	0
RESIDENTIAL	Water Bed	2,150		0		0	0
INDUSTRY	Glass manufacturing	877		128		0	0
INDUSTRY	Cement, Hydraulic	1,636		38		0	0
RESIDENTIAL	Pool Pump	3,024		0		0	0
RESIDENTIAL	Solar Pool Heating	0		64		0	0
RESIDENTIAL	Refrigeration	13,282		0		0	0
RESIDENTIAL	Solar Heater Pump	97		0		0	0
RESIDENTIAL	Hot Tub Pump	901		0		0	0
TCU	Water Transportation	48		0		0	0
TCU	Pipeline	935		16		0	0
COMMERCIAL	Heating	2,625		670		0	0
COMMERCIAL	Indoor Lighting	31,568		0		0	0
COMMERCIAL	Office Equipment	1,405		0		0	0
COMMERCIAL	Outdoor Lighting	5,332		0		0	0
COMMERCIAL	Ventilation	9,325		0		0	0
STLT	Street lighting and Traffic Control	1,713		0		0	0
RESIDENTIAL	Central Air Conditioning	4,199		45		0	0
RESIDENTIAL	Color Television	3,425		0		0	0
RESIDENTIAL	Freezer	2,461		0		0	0
RESIDENTIAL	Furnace Fan	1,273		0		0	0
RESIDENTIAL	Room Air Conditioner	486		0		0	0
RESIDENTIAL	Central Space Heating	3,245		2,339		0	0
TCU	Other Local Transportation, Parking Garages	212		5		0	0
TCU	Trucking and Warehousing	545		2		0	0
TCU	Post Office	528		3		0	0
TCU	Shipping Terminals	262		1		0	0
TCU	Air Transportation, Carrier	121		2		0	0
TCU	Transportation Service	201		2		0	0
TCU	Telegraph Communication	6		0		0	0
TCU	Radio and Television	461		1		0	0
TCU	Cable TV	514		1		0	0
TCU	Railroad Transportation	143		3		0	0
TCU	Rapid Transit	400		5		0	0
TCU	Sanitary Service	2,012	1.00	27	1.00	2,012	27
	Totals	**250,494**		**13,571**		**48,012**	**4,284**
	Percent					**19%**	**32%**

This table comes from the California Energy Commission's Demand Analysis Office. The data are for 2001 and are based on energy utility reporting for that year. They also include self generation above 1 MW. The percent of the energy related to water was discussed by the WER Working Group on July 29, 2005. If we agreed that most of the energy was water related, we assigned it a 1. If we knew there was a relationship but didn't understand enough to know how big, we assigned it 0.05. If there was some intermediate relationship, we assigned it 0.5, except for National Security and International Affairs which we felt was typical of the overall energy relationship to water. We assigned zero to those categories where there did appear to be a relationship.

APPENDIX C: ENERGY IMPACT ANALYSIS OF EXISTING WATER MANAGEMENT PRACTICES

Introduction

This appendix examines various water management practices focused on water conservation and efficiency and estimates the effects of water efficiency activities on energy savings. The analysis in this appendix is intended to:

- ✓ Quantify energy requirements in water use cycle processes.
- ✓ Determine current water efficiency measure energy impacts.
- ✓ Compare water and energy efficiency program characteristics.
- ✓ Recommend policy changes to incorporate water efficiency in the energy efficiency portfolio.
- ✓ Identify areas of research to better understand water-energy interdependencies.

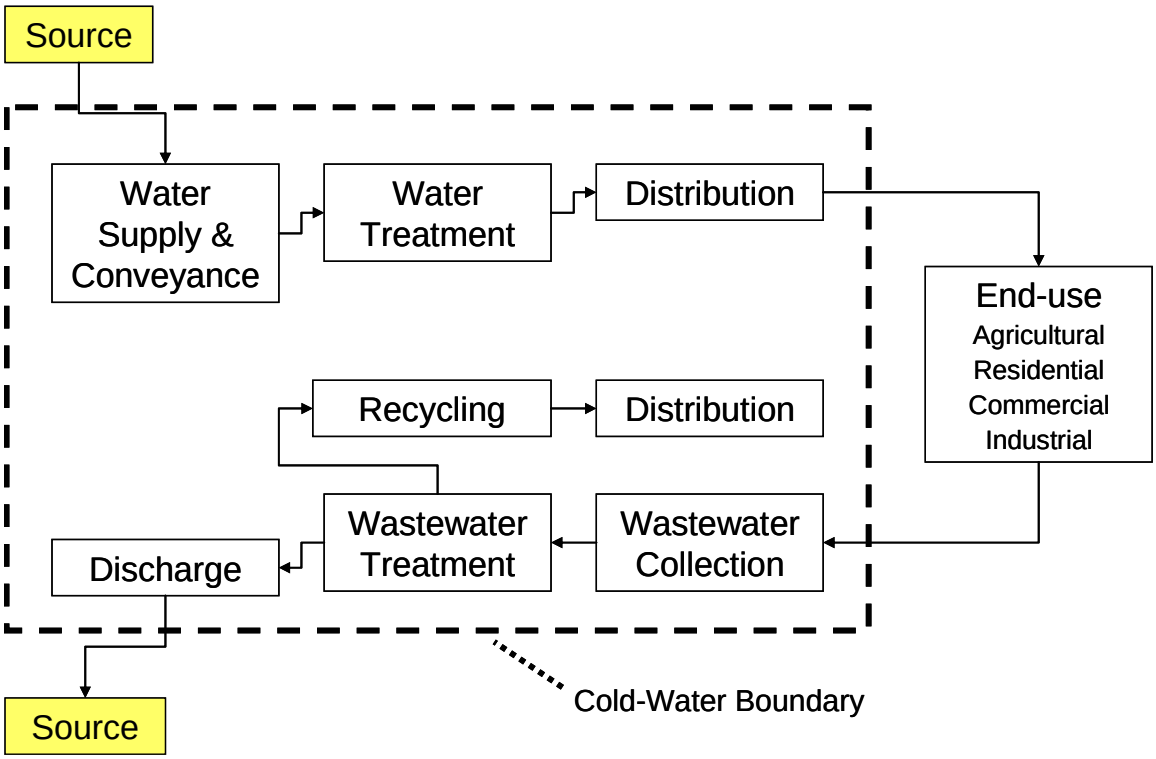
The Water Use Cycle

Electric and natural gas energy efficiency programs focus primarily on the application of energy consuming end-use technologies at utility customer facilities. In contrast to conservation, where usage is reduced through end-user behavioral changes, energy efficiency program planners target more permanent efficiency gains through known end-use technology or design applications. Likewise water use efficiency is achieved by implementing measures that result in reduced water consumption without customer behavioral changes.

In water systems, energy utilities target efficiency gains primarily by improving heating and pressurizing processes. For example, a low-flow showerhead saves energy because less hot water is used, thereby reducing the amount of energy needed to heat water. This is the case for water efficiency measures included in past energy efficiency programs such as faucet aerators, high-efficiency washing machines, and restaurant pre-rinse valves. Energy efficiency programs target efficiency gains in pressurizing applications by improving electric motor and/or pump efficiencies often at water and wastewater utility facilities. In each case the application is an end-use energy consuming technology located behind a customer meter.

When a unit of water is saved, so too is the energy required to convey, treat, deliver, perform wastewater treatment, and safely dispose of that unit of water. The energy intensity of the water use cycle must be examined on a systemic basis and varies widely by delivery location. Figure C-1 identifies the boundary of the water use cycle, showing the water processes that require energy, defined as cold water energy.

Figure C-1 Water Use Cycle



Significant customer-end use energy and water efficiencies have been, and are yet to be, achieved in the water sector[66]. These customer end-use efficiencies, while important, are excluded from this analysis to bring visibility to incremental cold-water energy savings.

When a water efficiency measure is implemented, the cold-water energy savings are achieved at multiple locations often transcending utility, city, and county jurisdictional boundaries. This analysis addresses the integration of water and energy demand-side management to increase cold water energy efficiency gains.

Water Use Cycle Energy Requirements

Electricity used to move or process water supplies (described above as cold water related energy) is quantified below in four primary stages or processes: conveyance, treatment, distribution, and wastewater treatment. The following table documents

[66] Even after accounting for expectations from existing efforts in this area, an additional 30-50 percent urban water (and associated energy) savings are possible with cost-effective existing technologies. (Waste Not, Want Not: The Potential for Urban Water Conservation in California, Pacific Institute, 2004.)

ranges of energy intensity for each process in terms of kilowatt-hours (kWh) per million gallons (MG):

Table C-1 Range of Energy Intensities for Water Use Cycle Processes (kWh/MG)

Water Cycle Segments	Low	High	Assumptions (Numbers in parentheses refer to sources listed below in this table)	
1. Water Supply & Conveyance	0	14,000	0: 14,000:	(1) Assume total gravity feed; (2) pg. 27 - SWP @ Pearblossom 4,444 kWh/AF or 13,638 kWh/MG (14,000 kWh/MG)
2. Water Treatment	100	16,000	100: 16,000:	(3) Water treatment without raw water pumping (max. gravity feed) and distribution pumping (accounted for under Distribution) = 99.7 kWh/MG Table 2-1, page 2-3 (7) Sea Water Desalination
3. Water Distribution	700	1,200	700: 1,200:	(6) (3) High Service Pumps To Distribution - 12,055 kWh/day for a Typical 10 MGD Surface Water Treatment Plant - figure 2-1, page 2-2 equivalent to 1,205.5 kWh/MG
4. Waste Water Collection	-	-		This category has been incorporated into the next category.
5. Waste Water Collection & Treatment	1,100	4,600	1,100: 4,630:	(4) Electric Use of Total Plant Operations Exec-1 and pg. 5, Table 3 - Range from 1,073 kWh/MG to 4,630 kWh/MG (3) Influent wastewater pumping is included in wastewater treatment process; figures 3-2 and 3-3, pages 3-3 and 3-4, respectively
6. Waste Water Discharge	0	400	0: 400:	(1) assumes gravity ocean outfall; 400 ground water recharge (3) pg. 3-7
7. Recycled Water Treatment	-	-		(4)(5) Tertiary/Advanced Waste Water Treatment Included under range of Waste Water Collection & Treatment
8. Recycled Water Distribution	400	1,200	Range:	(5) Municipal Recycled Water Use in California 2002: 46% Ag. Irrigation; 21 % landscape irrigation; 10% ground water recharge; Industrial 5%. This accounts for 82% of all recycled water. Energy needed for these applications fall within the ranges of the energy needed for typical water distribution and ground water recharge 400 - 1200 kWh/MG.

Sources:
(1) - Water Energy Working Group Assumption
(2) - Methodology for Analysis of the Energy Intensity of California's Water Systems; LBL January 2000
(3) - Water & Sustainability (Volume 4): U.S. Electricity Consumption for Water Supply & Treatment, EPRI March 2002
(4) - Energy Benchmarking Secondary Wastewater Treatment and Ultraviolet Disinfection Processes at Various Municipal Wastewater Treatment Facilities, PG&E February 2002
(5) - DWR Water Facts No. 23
(6) - EBMUD 2003 Load Study by Navigant Consulting
(7) - California Water Plan Update 2005 Volume 2, Resource Management Strategies, Chapter 6 – Desalination. A 50 mgd seawater plant (approximately 50,000 acre-feet per year, or 16.25 billion gallons, assuming operations 90% of the time) would require about 33 MW of power. California Water Plan Update 2005 Volume 2, Resource Management Strategies, Chapter 6 – Desalination. This translates to about 5,200 kWh per acre-foot, or 16,000 kWh per million gallons

Regional Water-Energy Characteristics

The ranges of water use cycle energy requirements identified above vary significantly because of regional water system operating requirements. To project energy savings associated with unit volume reductions in water requires adoption of prototypical energy needs, incorporating the variability inherent in regional resource alternatives. Analysis in this appendix separates water energy regions broadly into the Northern and Southern California regions, but additional research to assess regional water-energy characteristics is needed (see Suggested Research Topics, below).

The Northern California Region: Contains the North Coast, San Francisco, Sacramento River, San Joaquin River, Tulare Lake and Central Coast[67] Hydrologic Regions as defined by the California Department of Water Resources. The Northern California region contains 42 percent of the state's population and 42 percent of urban residential and non-residential applied water[68]. The region is characterized overall by relatively higher annual precipitation than in Southern California and significant native ground and surface water resources.

The Southern California Region: Contains the South Coast Hydrologic Region; 53 percent of the state's population and 48 percent of urban residential and non-residential applied water[69]. The region is characterized by relatively low annual precipitation and limited native surface water resources and has historically relied heavily on groundwater and imported water to meet water demand.

Other Hydrologic Regions: Hydrologic regions not included in this analysis are the North Lahontan, South Lahontan and Colorado River Hydrologic Regions[70]. Future studies will need to refine analyses addressed herein and incorporate these regions.

For purposes of this analysis, the Northern and Southern California regions, as referred to in this appendix, include 95 percent of the state's population and 90 percent of urban residential and non-residential applied water.

Water Use Cycle Energy Intensity

Table C-2 reflects the variability between water use cycle energy requirements between Northern and Southern California.

[67] The Central Coast hydrologic region includes Santa Barbara and San Luis Obispo Counties that are served by the SWP Coastal Branch with transport energy intensity on-par with the SWP West Branch (water must be lifted over the coastal mountain range). For the purposes of this analysis, the Central Coast is included in the Northern California region because 80 percent of the population within the Central Coast Hydrologic region resides north and east of the mountain range in communities such as Salinas, Santa Maria, Santa Cruz, Lompoc, and Monterey.

[68] Department of Water Resources 2005 Water Plan Update, Volume 3, Chapter 1 Table 1-4. Year 2000 is referenced for all regional characteristics and is described (same reference Table 1-1, page 1-10) as the "Average Year" within the context of precipitation and Wet versus Dry Years.

[69] Ibid

[70] North Lahanton is the extreme northeast of the state; South Lahanton is the region east of the Sierra Nevada Mountains including Mono Lake, Owens Valley and Death Valley; Colorado River Hydrologic Region include eastern San Bernardino, Riverside and Imperial Counties.

Table C-2 Percent Electricity Use for Water System Components[71]

	Northern California	Southern California
Imported Water Supply	-	71%
Local Ground/Surface Water Supply	17%	6%
Local Distribution	26%	9%
Wastewater Treatment	56%	14%

As reflected in Table C-2, the majority of the water use cycle energy required for Southern California, due to imported water, is not present in Northern California. To define process energy savings from water unit volume reductions, representative applications have been adopted for each primary process type: conveyance, treatment, distribution, and wastewater treatment. Energy use scenarios adopted and supported here are based on prototypical values for each process type. For purposes of this analysis, north/south water conveyance energy requirements are addressed separately and water treatment, distribution, and wastewater treatment assumptions are constant.

Water Conveyance

Northern California: As described in Table C-1, the range of water energy intensity for supply and conveyance ranges from 0 to 14,000 kWh/MG. Zero is assumed for gravity-fed systems. Water supplies from native surface water and groundwater sources require much less energy per unit conveyed than in Southern California. Approximately 60 percent of Northern California's urban water requirements are met with surface water and 40 percent is met with groundwater[72]. Additionally, roughly 40 percent of the region's population is located in the San Francisco Hydrological Region, where much of the water is conveyed by gravity from higher elevation reservoirs.

In this analysis, a prototypical value for water conveyance for Northern California is taken from the raw water pumping requirements of surface water treatment, based

[71] Methodology for Analysis of Energy Intensity of California's Water Systems and An Assessment of Multiple Potentials Benefits through Integrated Water-Energy Efficiency Measures; Exploratory Research Project Supported by: Ernest Orlando Lawrence Berkeley Laboratory, California Institute for Energy Efficiency; Principle Investigator Robert Wilkinson, PhD. January 2000, pg-7.

[72] Surface water and groundwater supply percentages are calculated using Water Supply and Use information provided in the California Water Plan Update 2005, Volume 3 for the California Department of Water Resources' North Coast, San Francisco, Sacramento River, San Joaquin River, Tulare Lake, and Central Cost Hydrological Regions.

upon a survey of approximately 30,000 public water supply systems in the United States[73] (see Water Treatment, below) and is estimated at 150 kWh/MG[74].

Southern California: Groundwater meets 23 and 29 percent of Southern California's water demand in normal and dry years, respectively[75]. The Metropolitan Water District (MWD) of Southern California provides 85 percent of the region's water supply to 26 cities and water districts serving 18 million people[76]. MWD's *Integrated Resource Plan* cites goals to mitigate heavy dependence on imported water by balancing its supply portfolio between imports; storage and transfers; recycling; groundwater recovery; conservation; brackish and seawater desalination; and exchanges[77]. While the region's water agencies have compiled a wide array of water management tools and planning practices to bring local water resources on a more equal footing, the region remains dependent on imported water for at least 50 percent of its water supplies[78].

As water agencies develop and employ least-cost resources to meet regional water demands, imported water serves as the primary baseline or "marginal resource." The 2003 *Qualifying Settlement Agreement* enabled implementation of the "4.4 Plan," where California will reduce its use of Colorado River water from a high of 5.3 million acre-feet to its 4.4 million acre-feet annual apportionment, by year 2016[79]. For Southern California, State Water Project (SWP) water supplies from Northern California are treated as the marginal water resource. A brief description of SWP water delivery to Southern California follows:

> As the California Aqueduct moves water south along the west side of the San Joaquin Valley, four pumping plants raise it more than 1,000 feet before reaching the Tehachapi Mountains. Pumps situated at the foot of the mountains pump the water up 1,926 feet through tunnels, which take the water into the Antelope Valley. In the Antelope Valley, the aqueduct divides into two branches: the East Branch and the West Branch.

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[73] Water & Sustainability (Volume 4) U.S. Electricity Consumption for Water Supply & Treatment – The Next Half Century, EPRI 2002, Page 2-3

[74] Ibid, Figure 2-1, page 2-2, Raw Water Pumping 1,205 kWh per day for a treatment plant with 10 MGD capacity; equivalent to 120.5 per MG; assumption is raised to 150 kWh/MG as a minimum prototypical energy requirement.

[75] Ibid, Chapter 5, page 5-3

[76] Ibid, pages 5-2 and 3.

[77] MWD presentation to the Water Energy Working Group April 8, 2005.

[78] Ibid, page 5-5

[79] Department of Water Resources 2005 Water Plan Update, Volume 3, Chapter 5, page 5-8

> The East branch carries water through the Antelope Valley into Silverwood Lake in the San Bernardino Mountains. From Silverwood Lake, the water flows through the San Bernardino Tunnel, through the Devil Canyon Power Plant before continuing on to the southernmost SWP reservoir, Lake Perris. East Branch water energy intensity, net of any SWP system generation, is 3,236 kWh per acre-foot, or 9,931 kWh per MG. Water in the West Branch flows through the Warne Power Plant into Pyramid Lake in Los Angeles County. From there it flows through the Angeles Tunnel and Castaic Power Plant into Castaic Lake, terminus of the West Branch. West Branch water energy intensity, net of any SWP system generation, is 2,580 kWh per acre-foot, or 7,918 kWh per MG[80].

For purposes of this analysis, the energy intensity of Southern California's dominant and marginal water source, averaged between the SWP East and West Branch, is 8,924 kWh/MG (rounded off to 8,900 kWh/MG).

Water Treatment

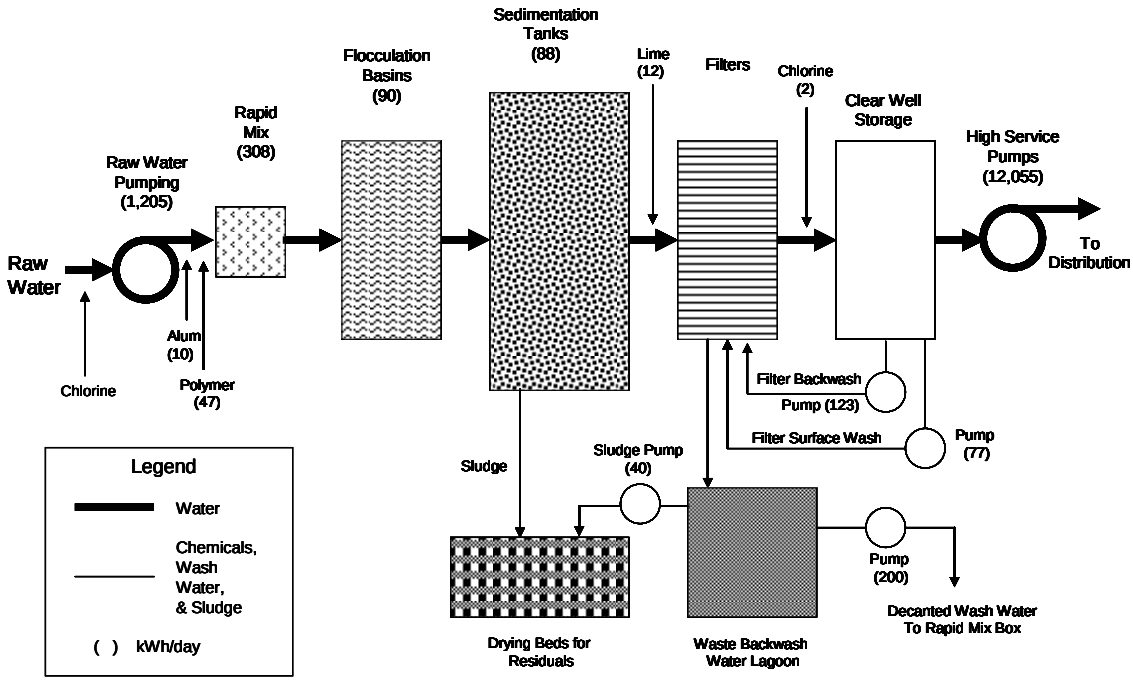
As explained above, for purposes of this analysis, water supply and conveyance energy requirements were addressed separately for Northern and Southern California. The remaining processes, water treatment, distribution, and wastewater treatment are considered similar enough between the two regions to assign the same prototypical water energy intensity. Due to the relative reliance on surface water supply in California, surface water treatment energy intensity has been adopted as prototypical.

In a typical sequence of operations for surface water treatment, the following steps are followed (see Figure C-2): Raw water is first screened and pre-oxidized, using chlorine or ozone to kill organisms; alum and/or polymeric materials are added to the water; flocculation and sedimentation remove finer particles; a second disinfection step kills remaining organisms with disinfectant residue carried into the distribution system to prevent organism growth; the clear well storage tank allows contact time for disinfection; and treated water is distributed to consumers by high-pressure pumps. Sludge and other impurities removed from the water are concentrated and disposed of.

[80] Methodology for Analysis of Energy Intensity of California's Water Systems and An Assessment of Multiple Potentials Benefits through Integrated Water-Energy Efficiency Measures; Exploratory Research Project Supported by: Ernest Orlando Lawrence Berkeley Laboratory, California Institute for Energy Efficiency; Principle Investigator Robert Wilkinson, PhD. January 2000, pages 24 through 27.

Figure C-2 Water Treatment Process Energy Requirements[81]

Representative Water Treatment Plant
Typical Daily Electricity Consumption for a 10 Million Gallon/Day Facility



Source: Electric Power Research Institute

[81] Water & Sustainability (Volume 4) U.S. Electricity Consumption for Water Supply & Treatment – The Next Half Century, EPRI 2002, Page 2-2, Figure 2-1.

Table C-3 Water Treatment Energy Intensity *(based on Figure C-2)*

		Surface Water Treatment Typical 10 mgd facility	kWh/MG
Public Supply	(Conveyance)	Raw Water Pumping	120.5
	(Treatment)	Alum	1.0
		Polymer	4.7
		Rapid Mix	30.8
		Flocculation Basins	9.0
		Sedimentation Tanks	8.8
		Lime	1.2
		Filters	0.0
		Chlorine	0.2
		Clear Well Storage	0.0
		Filter Backwash Pump	12.3
		Filter Surface Wash Pump	7.7
		Decanted Washwater to Rapid Mix	20.0
		Sludge Pump	4.0
		Treatment Subtotals	99.7
	(Distribution)	High Service Pumps	1,205.5
		Total	1,425.7

There is little variation in water energy intensity between plant sizes (shown in million gallons per day (MGD), as reflected in the following table:

Table C-4 Unit Electricity Consumption for Surface Water Treatment Plants[82]

Plant Size	kWh/MG
1 MGD	1,483
5 MGD	1,418
10 MGD	1,406
20 MGD	1,409
50 MGD	1,408
100 MGD	1,407

Referring back to Table C-3, in order to isolate the energy requirements for water treatment, the energy needed for raw water pumping and high service pumps to distribution have been removed. The remaining treatment processes total 997 kWh

[82] ibid, Page 2-3, Table 2-1. However, this study omitted the decanted wash water to rapid mix box pump rated at 20 kWh/MG from its totals. This amount was included in the numbers in the table.

per day for a typical 10 MGD capacity treatment plant or 99.7 kWh/MG. Actual energy requirements are driven by the site-specific characteristics of incoming raw water and water quality mandates. Industry standard practice, as well as process load metering, often doesn't differentiate raw water pumping, water treatment and distribution pumping loads adequately. Information provided in Table C-3 is drawn from large treatment plant populations and demonstrates this practice. Operational reporting of water treatment energy intensity is often driven more by the distance and elevation of the treatment plant in relation to water sources and the water distribution system than by the characteristics of raw water due to these vagaries. Typical water treatment processes are estimated at between 100 and 250 kWh/MG, and can be as high as 500 kWh/MG. In this analysis, 100 kWh/MG has been adopted as the prototypical and conservative water treatment energy intensity.

Water Distribution

Table C-4 shows there is little variation in the amount of energy required to treat and distribute a unit of water, regardless of plant size. As described above, Service Pumps to Distribution (for a typical 10 MGD water treatment plant) consume 12,055 kWh per day or 1,205.5 kWh per MG, or roughly 85 percent of total energy requirements (1,205 kWh/MG/1425 kWh/MG). For purposes of this analysis, a prototypical water distribution system energy intensity of 1,200 kWh/MG was adopted.

Wastewater Treatment

Unlike the water treatment and distribution systems, unit volume energy requirements for wastewater treatment plants vary greatly depending upon plant size. As would be expected, unit electricity consumption rises as the degree of treatment and complexity of the process increases. For example, advanced wastewater treatment with nitrification is three times as energy intensive (due to additional pumping requirements) as the relatively simple trickling filter plant[83]. Further complicating the assessment of prototypical wastewater treatment energy intensity are unique operational environments, discharge limitations, influent characteristics, and permitted effluent limitations as well as variations in plant permitting cycles. Table C-5 shows wastewater treatment plant energy intensities reflecting a range of energy intensity for facilities operating in California and cited in studies. Based on this range, 2,500 kWh per MG has been adopted as the prototypical wastewater treatment energy intensity.

[83] ibid, Pages 3-4 & 5 and Table 3-1.

Table C-5 Wastewater Treatment Energy Intensity

	kWh/MG
Inland Empire Utilities Agency [A]	2,971
City of Santa Rosa [B]	2,920
East Bay Municipal Utilities District [C]	2,001
Metropolitan Water District [D]	2655
Methodology for Analysis of Energy Intensity in California's Water Systems [E]	1,911
Energy Down The Drain, The Hidden Costs of California's Water Supply [F]	2,302
Energy Benchmarking Secondary Wastewater Treatment [G]	2,625

[A] Average of Five Wastewater Treatment Plants, CALeep Program Analysis May 2005
Program 1241-04, Conducted under the Auspices of the California Public Utilities Commission
[B] Laguna Wastewater Treatment
Sonoma County August 2002 Greenhouse Gas Emission Analysis, Page B-7
[C] EBMUD Load Studies Prepared by Navigant Consulting, December 2004
[D] The Metropolitan Water District of Southern California estimates that the wastewater facilities in its service territory consume between 1,470 to 3,840 kWh/MG
[E] Methodology for Analysis of Energy Intensity in California's Water Systems, January 2000, P. 43
Wastewater Treatment Plants with Nitrification
Ernest Orlando Lawrence Berkeley Laboratory
Principal Investigator: Robert Wilkinson, Ph.D.
Ref.: Burton, Franklin L. (Burton Engineering) , 1996 Water and Wastewater Industries
Electric Power Research Institute Report CR-106941, p. 2-45
[F] Wastewater Treatment with Nitrification (average 1-100 mgd plant capacities)
Energy Down The Drain, p. 26
[G] Energy Benchmarking Secondary Wastewater Treatment and Ultraviolet Disinfection Processes at Various (nine) Municipal Wastewater Treatment Facilities, PG&E February 2002
Electric Use of Total Plant Operations Exec-1 and pg. 5, Table 3 - 1,073 kWh/MG
Electric Use of Total Plant Operations Exec-1 and pg. 5, Table 3 - 4,630 kWh/MG

Summary of Water Energy Intensity for Northern and Southern California

The rest of this analysis is based on the following estimated energy intensities per million gallons of water (kWh/MG) delivered, treated, distributed, and disposed of in Northern and Southern California:[84]

[84] ibid (In this example NorCal system-wide Supply is estimated at 30 percent).

Table C-6 Prototypical Water Use Cycle Process Energy Intensity

	Northern California kWh/MG	Southern California kWh/MG
Water Supply and Conveyance	150	8,900
Water Treatment	100	100
Water Distribution	1,200	1,200
Wastewater Treatment	2,500	2,500
Total	3,950	12,700
Adopted	4,000	12,700

The Energy Efficiency of Water Use Efficiency

Energy savings associated with water savings provided in Table C-7 support the inclusion of water efficiency measures in energy efficiency program portfolios because of their relative low cost, long service life, and high resource value in terms of the avoided cost of energy. The following table reflects traditional water efficiency measures and their associated cold water energy savings resource values.

Table C-7 Water Efficiency Measure Cold Water Energy Savings

			Northern California			Southern California		
	Annual Savings Gallons/Year	Service Life	Annual kWh	Life-Cycle kWh	Resource Value	Annual kWh	Life-Cycle kWh	Resource Value
Residential								
Toilet Replacement 1.6 gpf (pre-1992)	2,250	25	9	225.0	$9	29	714	$32
Ultra Low-Flow Toilets	11,340	25	45	1,134.0	$44	144	3,600	$159
Energy Star Washing Machine	7,866	15	31	471.9	$27	100	1,498	$81
Commercial								
Ultra Low Flush Urinals	13,323	25	53	1,332	$52	169	4,230	$187
Waterless Urinals	25,568	25	102	2,557	$101	325	8,118	$359
Cooling Tower Condition Meter	729,906	10	2,920	29,196	$1,961	9,270	92,698	$5,609
Pre-Rinse Spray Head Installation	87,120	5	348	1,742	$136	1,106	5,532	$395
X-Ray Processor	1,042,723	5	4,171	20,854	$1,627	13,243	66,213	$4,733

Cost-effectiveness Assumptions

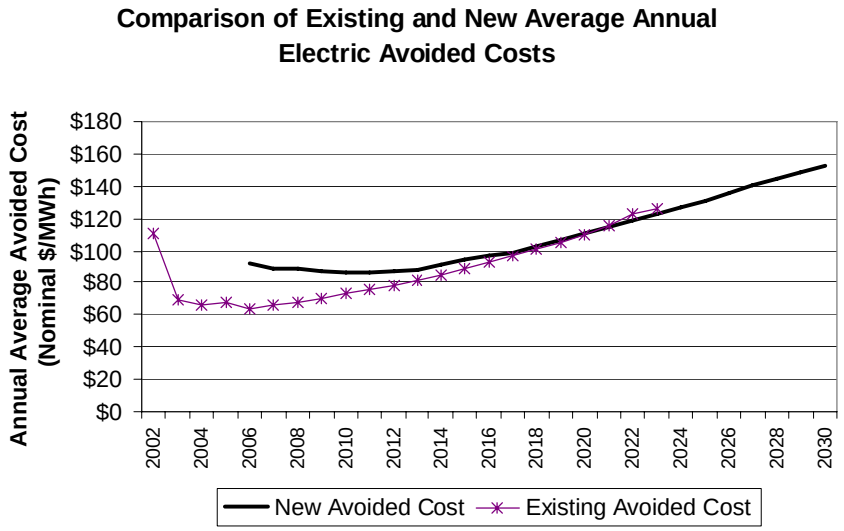
Resource values in this appendix were developed using the E3 Avoided Cost Methodology adopted by the California Public Utilities Commission (CPUC) in the April 7, 2005, Decision 05-04-024, Rulemaking (R.) 04-04-025. The CPUC adopted the E3 methodology for purposes of evaluating energy efficiency programs in R.01-08-028 and related energy efficiency proceedings.

The E3 model incorporates market price effects; the value of reliability through ancillary services; and the disaggregation of the avoided costs to time (hour, month, or time-of-use period) and to California climate zones. The E3 model forecasts the avoided costs of electric generation, transmission, and distribution that vary by hour, and the avoided costs of natural gas procurement, transportation, and delivery, which vary by month. Transmission and distribution (T&D) costs vary by utility service territory, planning division, and by the 16 Title-24 climate zones. Externality adders report environmental externalities: a T&D adder, which captures incremental demand-related capital expenditures, line losses and maintenance costs associated with increased energy use; a system reliability adder, which includes the cost of maintaining a reserve margin; and a price elasticity of demand adder, which recognizes that reduced demand results in a decrease in market-clearing price for electricity and therefore an increase in consumer surplus. The price elasticity of demand estimate varies by time-of-use period and month.

As currently utilized by the CPUC and energy utilities, the avoided cost projections in the E3 methodology extend to 2025. The calculations in this appendix include water use efficiency measures with 25-year service lives requiring that avoided cost projections be extended to 2030. The energy utilities submitted advice letter filings to the CPUC in April 2005 for purposes of updating their avoided cost projections. These filings projected utility avoided costs through 2030 for incorporation into the E3 methodology for valuing their energy efficiency resources. Figure C-3[85] compares the average utility avoided cost in place before and after the advice letter filings.

[85] Figure comes from E-3 published analysis of new and existing utility avoided costs.

Figure C-3



Source: E3

To calculate the resource value associated with the water use efficiency measures, the E3 methodology was modified to extend avoided cost projections to 2030. The adjustment from a 20-year to a 25-year measure results in less than a 7 percent change in the stated energy resource values. This means that the significant resource value potentials identified later in this appendix are not contingent upon modifying the avoided cost projections. E3 reviewed the adjustments and agreed the calculations were performed correctly.

Cold water energy savings are realized when one or more elements of the water use cycle - water conveyance, water treatment, water distribution systems and wastewater treatment facilities - process less water. They are also realized by avoiding incremental growth and requirements for plant expansions. In both cases the energy savings in the water use cycle result from the water use efficiency measures that were implemented. In this analysis water use cycle processes are assumed to operate 24 hours per day with an 85 percent load factor.

Energy Value of 2004 Best (Water) Management Practices

At a programmatic level, the California Urban Water Conservation Council (CUWCC) was created through the *Memorandum of Understanding (MOU) Regarding Urban Water Conservation in California* in 1991 to manage the process of implementing and updating the list of Best [water] Management Practices (BMP). To date 189 water agencies have pledged to implement the BMPs. CUWCC BMPs serve as a framework to quantify the energy resource value associated with water efficiency. The current lists of BMPs developed by the CUWCC follow.

Table C-8 CUWCC Best Management Practices[86]

BMP	Quantifiable Results
BMP 01: Water Survey Programs for Residential Customers	X
BMP 02: Residential Plumbing Retrofit	X
BMP 03: System Water Audits, Leak Detection and Repair	
BMP 04: Metering with Commodity Rates for all New Connections and Retrofit of Existing	X
BMP 05: Large Landscape Conservation Programs and Incentives	X
BMP 06: High-Efficiency Washing Machine Rebate Programs	X
BMP 07: Public Information Programs	
BMP 08: School Education Programs	
BMP 09: Conservation Programs for CII Accounts	X
BMP 09a: CII ULFT Water Savings	X
BMP 10: Wholesale Agency Assistance Programs	
BMP 11: Conservation Pricing	
BMP 12: Conservation Coordinator	
BMP 13: Water Waste Prohibition	
BMP 14: Residential ULFT Replacement Programs	X

Source: California Urban Water Conservation Council

[86] Quantifiable means annual reported BMP water use efficiency savings in acre feet per year, net of plumbing code compliance savings, reported pursuant to the 1991 Memorandum of Understanding Regarding Urban Water Conservation in California under protocol set forth by CUWCC. References: CUWCC (2005) *BMP Costs and Savings Study - A guide to Data and Methods for Cost-Effectiveness Analysis of Urban Water Conservation Best Management Practices* and (2003) *First Partial Revision*; M. Cubed (2003) *BMP Reporting Database Water Savings Calculations*; M. Cubed (1997) *California Urban water Agencies BMP Performance Evaluation, Final Report*; A&N Services (1996) *Guidelines to Conduct Cost-Effectiveness Analysis of Urban Water Conservation Best Management Practices*; U.S. EPA (1994) *Customer Incentives for Water Conservation, A Guide,* EPA/X820683-01-1, U.S. Environmental Protection Agency, Washington, DC. Measurement and evaluation is addressed by the CUWCC Measurement & Evaluation Committee.

To provide visibility to the potential impacts of integrated resource planning for water and energy efficiency programs, 2004 water sector BMP achievements were examined using the adopted energy efficiency avoided cost valuation methodology[87]. This analysis combines known planning criteria from each industry to assess the efficiency gain potential though programmatic integration.

Quantifiable water savings are available for eight of the BMPs, as shown in Table C-8. Each BMP includes several related water use efficiency measures. Assumptions for the water savings of each measure in gallons per day (GPD) and measure service life are reflected below in Table C-9.

[87] Resource values are produced using the E3 Avoided Cost Methodology adopted by the CPUC in the April 7, 2005 Decision 05-04-024, Rulemaking (R.) 04-04-025. The Commission adopted the E3 Methodology for the purposes of evaluating energy efficiency programs in R.01-08-028 and related energy efficiency proceedings. Avoided cost bases are maintained at the website http://www.ethree.com/CPUC/cpucAvoided26.xls

Southern California Resource Values: The E3 calculator utilized is version "SCE Tool 1q" and incorporates SCE's update to the E3 Methodology as described in SCE Advice 1187-E (U-338-E) of April 25, 2005 specifically "extending the avoided cost forecast to 25 years from the base year of 2006" and applying "a linear trend based on the last five years of data contained in the E3 Methodology" as described in the referenced Advice Letter, page 3, Section A.

Northern California Resource Values; The E3 calculator utilized is version "CEE_Calc_Tool_Commercial_1d" and incorporates PG&E's update to the E3 Methodology as described in PG&E Advice 2626-G/2654-E (U-39-M) of April 25, 2205 and reflect ATTACHMENT A, Table 4: Adjustments Made to Extend Forecast through 2030.

Table C-9 BMP Water Use Efficiency Measure Service Life and Savings

	Service Life	Savings gpd	Reference
BMP 01:	4.5	26.6	Residential Surveys: BMP Costs & Savings Study, Draft Revision March 2005, page 1-10 & 11, Table 1-3 (average of range)
	5	21.0	Residential Surveys, Single Family: Metropolitan Water District of Southern California (MWD) program planning assumptions
	4	8.8	Residential Surveys, Multi-Family: MWD program planning assumptions
BMP 02:	5.1		Residential Plumbing Retrofits: BMP Costs & Savings Study (July 2000 ed.), page 2-13, mid-point range, equivalent useful life five years April 28 2003 M. Cubed Technical Memorandum to M&E Committee re; BMP Reporting Database Water Savings Calculations - Page 4 of 15
	5	5.5	Low Flow Showerheads: BMP Costs & Savings Study, First Partial Revision December 2003, page 2-38, Table 1 Method 1 average
	3.5	4.2	Toilet Displacement Devices: BMP Costs & Savings Study, First Partial Revision December 2003, page 2-38, Table 1 Method 1 average
	2	1.5	Faucet Aerators: BMP Costs & Savings Study, First Partial Revision December 2003, page 2-38, Table 1 Method 1 average
	8.5	0.64	Toilet Leak Detection: BMP Costs & Savings Study, First Partial Revision December 2003, page 2-38, Table 1 Method 1 average
	8.5	0.5	Other Household Leak Detection: BMP Costs & Savings Study, First Partial Revision December 2003, page 2-38, Table 1 Method 1 average
	4	12.2	Turf Audit: BMP Costs & Savings Study, First Partial Revision December 2003, page 2-38, Table 1 Method 1 average
	4	25.9	Turf Audit With Timer: BMP Costs & Savings Study, First Partial Revision December 2003, page 2-38, Table 1 Method 1 average
	25	24.2	Ultra Low-Flow Toilets (ULFT): BMP Costs & Savings Study, Draft Revision March 2005, page 1-10 & 11, Table 1-3 (average of range)
	17.5		Hot Water on Demand: BMP Costs & Savings Study, Draft Revision March 2005, page 1-10 & 11, Table 1-3 (average of range)
BMP 04:	10.5	Reported	Metering With Commodity Rates: BMP Costs & Savings Study, Draft Revision March 2005, page 2-29 (though should probable be 20+, as if and when a meter fails, it would be replaced see Section 2.5
BMP 05:	10	Reported	Large Landscape: Budgets and Surveys: MWD Planning Practices; BMP Costs & Savings Study, Draft Revision March 2005, page 1-10 & 11, Table 1-3 (average of range) see Section 2.16
			Evapotranspiration (Eto)-based budgets: BMP Costs & Savings Study (July 2000 ed.), Table 1, page 53
			Large Landscape Surveys: Urban Water Conservation Potential (August 2001)
BMP 06:	14	21.6	H/E Washing Machines: BMP Costs & Savings Study, Draft Revision March 2005, page 1-10 & 11, Table 1-3 (average of range)
	15	21.6	BMP Costs & Savings Study, First Partial Revision December 2003, page A-6
		13.8	BMP Costs & Savings Study, First Partial Revision December 2003, page A-8 range average
BMP 09:	12.4		CII Conservation Programs: Urban Water Conservation Potential (August 2001) (decay rate 10%)
		527.5	CII Surveys: BMP Costs & Savings Study, Draft Revision March 2005, page 1-10 & 11, Table 1-3 (average of range)
	5	2,856.8	X-Ray Processor: MWD Program Planning assumptions
	3	136.6	Water Broom: MWD Program Planning assumptions
	5	300.0	Pre-Rinse Spray Head: BMP Costs & Savings Study, Draft Revision March 2005, page 1-10 & 11, Table 1-3 (average of range 100-500 gpd); expected life span see page 2-80
	3	200.0	MWD program planning assumptions
	5	240.0	PG&E Non-Residential Work Papers Supporting Application For Approval of 2006-2008 Energy Efficiency Programs and Budgets filed June 20 2005, R.01-08-028, pages 40 - 43 (electric) and 57 - 59 (gas) of 279, Non-Res Deemed Savings pages 14 or 20
	5	892.7	Industrial Process Improvement: MWD program planning assumptions
	8	103.6	High-Efficiency Washers: MWD program planning assumptions
	5	22.3	Flush Valve Kit: MWD program planning assumptions
	10	1,999.7	Cooling Tower Conditioning Meter: MWD program planning assumptions
BMP 09a:	25	36.5	CII ULFT Replacement: M. Cubed (2003) Technical Memorandum to the CUWCC M&E Committee re; BMP Reporting Database Water Savings Calculations - Page 10 of 15; BMP Costs & Savings Study, Draft Revision March 2005, page 1-10 & 11, Table 1-3 (average of range); BMP Costs & Savings Study, First Partial Revision December 2003, page A-12, Example 2A
	25	30.4	CII Dual Flush CII ULFT: MWD program planning assumptions
	30	30.1	Ultra Low-Flow Urinals: BMP Costs & Savings Study, Draft Revision March 2005, page 1-10 & 11, Table 1-3 (average of range)
	25	70.1	Waterless Urinals: BMP Costs & Savings Study, Draft Revision March 2005, page 1-10 & 11, Table 1-3 (average of range)
BMP 14:	25	31.1	Res - ULFT: BMP Costs & Savings Study, First Partial Revision December 2003, page A-12, Example 2A; MWD program planning assumptions; BMP Costs & Savings Study (July 2000 ed.), page 2-29; April 2003 Technical Memorandum, page 15 of 15

Source: California Urban Water Conservation Council

The CUWCC reporting system for reductions in water used by member agencies reflects 2004 BMP achievements for BMPs with quantifiable results.[88] The energy savings for these measures, both annual and life cycle, are shown for each of these measures in Table C-10.

[88] Data was obtained from public access CUWCC website http://bmp.cuwcc.org/bmp/summaries/public/bmpsavings.lasso

Table C-10 Energy Resource Value in Water Use Efficiency (2006-2008 (E3) Avoided Cost)[89]

Northern California (PG&E/SMUD)	MG	Annual Savings kWh	Useful Life	Life-Cycle kWh Savings	NPV Electric Avoided Cost
BMP 1 Water Survey Programs MF/SF	802	3,208,000	5	16,040,000	1,251,113
BMP 2 Residential Plumbing Retrofit	132	528,000	5	2,640,000	205,919
BMP 4 Metering & Commodity Rates	671	2,684,000	11	29,524,000	1,929,737
BMP 5 Large Landscape Conservation Programs	2,249	3,261,050	10	32,610,500	2,190,009
BMP 6 High-Efficiency Washing Machine Rebate	134	536,000	15	8,040,000	474,057
BMP 9 Conservation Programs CII	2,035	8,140,000	12	97,680,000	6,217,380
BMP 9a CII ULFT	109	436,000	25	10,900,000	430,340
BMP 14 Residential ULFT	5,490	21,960,000	25	549,000,000	21,674,941
Total Northern California	11,621	40,753,050			$34,373,496
Southern California (SCE/LADWP/SDG&E)					
BMP 1 Water Survey Programs MF/SF	1,095	13,906,500	5	69,532,500	4,969,753
BMP 2 Residential Plumbing Retrofit	180	2,286,000	5	11,430,000	816,946
BMP 4 Metering & Commodity Rates	916	11,633,200	11	127,965,200	7,543,053
BMP 5 Large Landscape Conservation Programs	3,072	31,334,400	10	313,344,000	18,959,692
BMP 6 High-Efficiency Washing Machine Rebate Program	183	2,324,100	15	34,861,500	1,872,831
BMP 9 Conservation Programs CII	2,779	35,293,300	12	423,519,600	24,350,142
BMP 9a CII ULFT	149	1,892,300	25	47,307,500	2,092,023
BMP 14 Residential ULFT	7,498	95,224,600	25	2,380,615,000	105,275,069
Total Southern California	15,871	193,894,400			$165,879,509
Total Statewide Impacts	27,492	234,647,450			$200,253,005

Source: CUWCC Reporting Database, April 2005 with 86 of 269 Reporting Units (32%) reporting BMP expenditures in 2004 Reporting Units include: Water utility districts, water agencies, irrigation districts, city and county water departments and, water service companies implementing BMPs.

The numbers shown in Table C-10 reflect the variability in water conservation impacts on water related energy requirements, depending upon measure location.[90] The energy values have been obtained based on the multipliers for Northern and Southern California. The landscape numbers assume that the applied water is not treated as wastewater. In addition to the more than 27 million gallons saved from the 2004 BMPs, 234 million kWh were also saved that year, worth more than $200 million over their useful lives.

At this time it is reasonable to use the energy intensity values contained in this appendix as proxy values to support program planning. Future analyses of water energy intensity should be refined geographically by applying characteristics of hydrologic regions, planning areas or detailed analysis units as required, and finally

[89] See footnote 83.

[90] Water conservation activity is reported by CUWCC aggregated; to support disaggregating between SoCal and NorCal, electric service customer populations were used to establish approximately 60 percent - 40 percent shares for SoCal and NorCal, respectively.

applied to a structure that will align with energy efficiency planning climate zones[91] (See Suggested Research Topics).

The need to measure location-specific water-energy efficiency impact does not constitute a programmatic barrier for energy efficiency planners. This treatment is consistent with current energy efficiency program planning practices. For example, all current weather-dependent energy efficiency measure savings reflect location-specific savings across 16 climate zones - for example heating; ventilation and air-conditioning as well as building envelope measures; insulation; window glazing; and infiltration. Therefore, adopting savings for water-energy efficiency reflecting regional water energy intensity could be readily incorporated into current energy efficiency program planning protocols. The key point is that regional variability in water energy intensity should not defeat integrated planning. Energy efficiency planning already addresses many efficiency measures with varying degrees of savings in 16 geographic climate zones.

Statewide Water Use Efficiency (WUE) Potential

While the energy saving potential of 2004 BMP results are significant, they in no way indicate statewide potential. As related above, this appendix relied on the CUWCC's reporting database and used CUWCC's BMP reporting structure to provide visibility for associated energy benefits. CUWCC stresses that the reported savings are conservative and "the database does not include water efficiency for a whole series of BMPs for which CUWCC did not have a method to calculate water savings"[92].

The Pacific Institute, in its November 2003 report *Waste Not, Want Not: The Potential for Urban Water Conservation in California*, cites water savings potential, reflected in Table C-11. The 2004 BMP reported results in Table C-10 that represent approximately 4 percent of the minimum potential cost-effective savings identified here.

[91] The California Department of Water Resources subdivides the state into 10 hydrological regions, 56 planning areas plus a more detailed breakdown into 278 detailed analysis units. Existing spatial analysis (GIS) readily supports integration of water measures into energy-efficiency program planning climate zones to ensure regional values align with energy-efficiency program planning protocols.

[92] Comments of Mary Ann Dickinson, Executive Director of the California Urban Water Conservation Council at the California Energy Commission Energy-Water Relationship Comment Workshop, Docket No. 04-IEP-01-H, June 21, 2005; Proceeding Minutes page 22.

Table C-11 California Urban Water Use in 2000

Potential to Improve Water Use Efficiency and Conservation

California Urban Water Use by Sector	Current (2000) Water Use (AF/year)	Best Estimate of Conservation (AF/year)	Potential to Reduce Use (%)	Minimum Cost-Effective Conservation (AF/year)
Residential Indoor	2,300,000	893,000	39	893,000
Residential Outdoor	983,000 to 1,900,000 (b)	360,000 to 580,000 (c)	25 to 40	470,000
Commercial/ Institutional	1,850,000	714,000	39	Combined CII: 658,000
Industrial	665,000	260,000	39	(e)
Unaccounted-for Water	695,000	(d)	(d)	(d)
Total	**6,960,000** (+/- 10%)	2,337,000	34	2,020,000

Source: The Pacific Institute

The question is really how much energy savings can actually be achieved through this much water use efficiency. The following calculations were performed to make this determination:

1. The average of *Best Estimate of [Water] Conservation* and *Minimum Cost-Effective Conservation* (Table C-11 above) is 2,178,500 acre feet per year, rounded to 2,150,000.
2. As shown in Table C-6 (and applied in Table C-11), the average energy intensity for Northern and Southern California is 4,000 and 12,700 kWh/MG, respectively; the weighted average based on customer populations is 9,220 kWh per MG[93].
3. 2,150,000 AF or 700,580 MG of California's achievable water conservation, multiplied by the 9,220 kWh per MG (the state's weight average water use cycle energy intensity), yields equivalent energy savings of 6,450 GWh, rounded to 6,500 GWh.

[93] The weight average of water use cycle energy intensity is based on year 2000 customer populations for Northern California of 5.167 million customers (PG&E and SMUD) and for Southern California of 7.057 million customers (SCE, LADWP and SDG&E) representing 92 percent of California's electric customers. This yields a customer allocation of 42.3 percent for Northern and 57.7 percent for Southern California. Applying the rounded allocation of 40 percent and 60 percent to respective energy intensities of 4,000 and 12,700 kWh per MG yields a population based weighted average of 9,220 kWh per MG.

4. 6,500 GWh and an 85 percent load factor yield a demand reduction of 873 MW, rounded to 850 MW.

   In Summary:

   - ✓ Annual water use efficiency water savings:
     - 700,580 MG
   - ✓ Water use cycle energy requirements:
     - 9,220 kWh/MG
   - ✓ Water use efficiency energy savings:
     700,580 (MG) X 9,220 (kWh/MG) = 6,459,344,373 kWh or 6,459 GWh
     Assumed Water Use Cycle Energy Savings = 6,500 GWh
   - ✓ Water use efficiency demand reduction:
     Peak Load (kW) = kWh / (Load Factor * 8760)
     Peak Load (kW) = 6,500,000,000 / (.85 * 8760) =
     873,000 kW or 873 MW
     Assumed Peak Load Reduction = 850 MW

5. Information from multiple sources shows that the cost of most water use efficiency measures ranges from about $58 to $710 per acre-foot or $178 to $2,179 per MG, depending upon the program. These costs include the full cost to manage the programs, capital investments, and required staffing[94]. Assuming an average of this range, or $384 per acre-foot ($1,178 per MG), the approximate cost in terms of energy efficiency is $0.13 per annualized kWh (700,580 MG X $1,178/MG = $825.6 million / 6,500,000,000 kWh = $0.127/kWh, rounded to $0.13/kWh).

Table C-12 presents the results of these calculations and compares them to the California's energy efficiency programs for 2004-2005 and those planned for 2006-2008.

[94] Department of Water Resources 2005 Water Plan Update, Volume 2, page 22-2, Potential Benefits of Urban Water Use Efficiency, and; Potential Costs of Urban Water Use Efficiency

Table C-12 Comparison of Water Use Efficiency to Energy Efficiency Resource Value

	2004-2005 [1]	2006-2008 [2]	WUE [3]
GWh (Annualized)	2,745	6,812	6,500
MW	690	1,417	850
Funding ($ million)	$762	$1,500	$826
Cost per Annual kWh	$0.28	$0.22	$0.13
WUE Relative Cost	46%	58%	

[1] CPUC Rulemaking R.01-08-028, Decision D.03-12-060
[2] CPUC Rulemaking R.-01-08-0228, Decision D.04-09-060
[3] California Water Plan Update 2005, Bulletin 160-05 California Department of Water Resources, page 22-2

The table shows that the estimated energy savings from statewide water use efficiency is more than double the energy savings from the 2004-2005 energy efficiency programs and almost as large as those planned for 2006-2008. The estimated peak reduction from water use efficiency falls between the values for these years. From a program cost standpoint, water use efficiency is roughly one-half the cost of energy efficiency programs.

These estimates are reasonably robust. If the energy savings were only half as much or if the costs were twice as much, water use efficiency would be as cost-effective as current and planned energy efficiency programs.

One of the questions that came up during the California Energy Commission's (Energy Commission) *Integrated Energy Policy Report (Energy Report)* proceedings was concerned with the different ways that water and energy programs address the useful life of the same measures. To evaluate the potential impact of this difference, Table C-13 compares several measures that are common to both energy efficiency and water use efficiency programs. The Estimated Useful Life (EUL) and energy savings from water heating and from savings in the water use cycle (cold water savings) are presented for four common measures:

Table C-13 Energy Efficiency – Water Use Efficiency Common Measures

	Energy - EUL	Water – EUL	Heating Annual Savings (kWh)	Cold Water Savings (kWh)
Low-Flow Showerhead[1]	10	5	202	16
Faucet Aerator[2]	10	2	78	4
Clothes Washer[3]	15	15	644	100
Pre-Rinse Spray Valve[4]	5	5	12,310	1,106

[1] Measure #504 California Statewide Residential Sector Energy Efficiency Potential Study #SW063
[2] Measure #506 ibid
[3] Measure #601 ibid
[4] PG&E CPUC Application for Approval of 2006-2008 Energy Efficiency Programs and Budget (U 39 M), Advice Letter 05-06-004 ATTACHMENT 4, ERRATA FOR PROGRAM DESCRIPTIONS, Workpapers

As shown above, water use efficiency planners apply estimated useful lives to the same measures that are either equal to or lower than those applied by energy efficiency planners. For purposes of consistency with the energy savings calculations shown later in this appendix, the EULs used by the energy planners were adopted.

Another concern was that these four measures represent the full potential for additional water use efficiency gains. However, the small set of overlapping measures represents less than 2 percent of the *known* energy savings and resource value that can be created through cold water savings. These additional savings – 98 percent - will come from measures that have been generally overlooked by energy efficiency planners.

At one time water use efficiency was narrowly viewed as a temporary source of water supply in response to drought or emergency water shortage situations. However, this analysis shows that water use efficiency is a viable long-term water and energy resource supply option. In short, significant, attainable energy savings can be realized in the form of water use efficiency.

Comparing Water and Energy Efficiency Programs

Comparing water and energy efficiency programs reveals differences in treatment in the following areas: program oversight, resource valuation, technical potential, budgets (trends), planning, implementation and evaluation, measurement, and verification. This section examines how both programs address these areas.

Program Oversight and Compliance

There is significant variability between water and energy efficiency program targets, regulatory oversight, and compliance. Targets for water conservation are referenced

to a 10-year reporting period. Performance requirements for the BMPs with quantifiable results follow in Table C-14:

Table C-14 Best Management Practices

BMP	Requirements
BMP 01: Water Survey Programs for Single-Family and Multi-Family Residential Customers	Survey 15 percent of residential customers within 10 years
BMP 02: Residential Plumbing Retrofit	Retrofit 75 percent of residential housing constructed prior to 1992 with low-flow showerheads, toilet displacement devices, toilet flappers and faucet aerators
BMP 04: Metering with Commodity Rates for all New Connections and Retrofit of Existing	Install meters in 100 percent of existing un-metered accounts within 10 years; bill by volume of water use; assess feasibility of installing dedicated landscape meters
BMP 05: Large Landscape Conservation Programs and Incentives	Prepare water budgets for 90 percent of commercial and industrial accounts with dedicated meters; provide irrigation surveys to 15 percent of mixed-metered customers
BMP 06: High-Efficiency Washing Machine Rebate Programs	Provide cost-effective customer incentives, such as rebates, to encourage purchase of machines that use 40 percent less water per load
BMP 09: Conservation Programs for CII Accounts	Provide a water survey of 10 percent of these customers within 10 years and identify retrofitting options; OR reduce water use by an amount equal to 10 percent of the baseline use within 10 years
BMP 14: Residential ULFT Replacement Programs	Replace older toilets for residential customers at a rate equal to that of an ordinance requiring retrofit upon resale

Source: California Urban Water Conservation Council

A consistent and broadly acceptable method to evaluate (water use efficiency) cost-effectiveness and water savings is needed[95]. Documentation and evaluation of the achievements attributable to water use efficiency projects and programs, vital elements of successful water use efficiency efforts, need to be improved. The quantification of benefits for many projects lacks a necessary level of scientific

[95] Ibid

rigor[96]. Implementation of the BMPs by the water agencies is voluntary, and water efficiency program performance is self-reported, monitored by the CUWCC[97]. CUWCC is a non-profit agency with its governance administered by a committee comprising six representatives: three representatives from member water agencies and three representatives from public advocacy organizations[98]. Not all water agencies have signed onto the MOU agreement, and not all signatories are fully implementing the BMPs[99].

In contrast, the state's investor-owned utilities (IOU) energy efficiency programs are regulated by the CPUC[100]. The requirements include:

- ✓ Administrative structure for efficiency programs
- ✓ Program evaluation, measurement, and verification (EM&V)
- ✓ Separation between "those who do" and "those who evaluate" programs
- ✓ Protocols for measuring efficiency programs are defined in the *Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand-Side Management Programs* [101]
- ✓ EM&V integration into the program planning process
- ✓ EM&V funding guidelines
- ✓ The type and frequency of EM&V studies conducted for each program and the major study parameters utilized for each study, including sample design, monitoring duration and schedule, and approaches undertaken to evaluate and minimize bias
- ✓ Cost-effectiveness tests used to evaluate program performance and proposed programs including:

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[96] Department of Water Resources 2005 Water Plan Update, Volume 2, page 22-4, WUE Challenges – Data Collection.

[97] CUWCC Governance Policies Section 10. Access to BMP Reporting Data: 10.1a.: "The Council will regard any data stored in the Council BMP Reporting Database that has been formally 'submitted as final" as public information', and; Section 10.1c.: "All publicly-released reports shall carry a disclaimer indicating that reports are based on self-reported data that has not been 100% validated by the Council."

[98] CUWCC Governance Policies Section 6.1, "The Council's Governance Committee shall be responsible for initiating the Executive Director's Annual Performance Review. The committee shall be responsible for oversight of Council governance, including review of bylaws, policies, membership development and training, communication (internal and external), strategic planning and meeting protocol." "The Governance Committee shall be composed of three Group 1 representatives (urban water supplier representatives) and three Group 2 representatives (public advocacy organizations) from the Steering Committee.

[99] Department of Water Resources 2005 Water Plan Update, Volume 2, page 22-3

[100] See CPUC Rulemaking 01-08-028, Decision 05-04-051 April 21, 2005

[101] As adopted by California Public Utilities Commission Decision 93-05-063 Revised March 1998 Pursuant to Decisions 94-05-063, 94-10-059, 94-12-021,95-12-054, 96-12-079, D.98-03-063, and D.99-06-052.

- program costs and participation levels
- number and type of measures
- environmental adders informed by and coordinated with the Climate Change Action Registry
- continuity of the input assumptions and calculations for the tests of cost-effectiveness (California Standard Practice Manual[102])
- *ex post* (after-installation) measurement of lifecycle savings inform and update *ex ante* (pre-installation) assumptions for future programs
- values for the weighted cost of capital (instead of using different values for each implementer). The current authorized cost of capital for the IOUs ranges between 7.6 percent and 8.7 percent, depending upon the IOU.

Program Funding

Variations in program oversight and compliance might reflect, in part, energy efficiency program ratepayer funding and funding levels. California electric industry deregulation legislation and other regulation established minimum levels of energy efficiency funding from 1998 through 2001, and are currently used by both IOUs and local publicly owned electric utilities[103].

Additionally, in 2003 the CPUC ordered IOUs to file plans to include energy efficiency as part of their long-term procurement supply portfolios for the first year, five years, and twenty years[104].

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[102]http://www.cpuc.ca.gov/static/industry/electric/energy+efficiency/rulemaking/03eeproposalinfo.htm

[103] Electric Industry restructuring legislation Assembly Bill 1890 (Brulte, 1996) codified in Public Utilities Code (PU Code) under Division 1, Part 1, Chapter 2.3. Electrical Restructuring. Under Article 7 Research, Environmental, and Low-Income Funds, Section 381 directed the CPUC to require each IOU to identify a separate rate component to collect revenues used to fund cost-effective energy efficiency and conservation activities. Herein the IOUs were directed to fund not less than the following levels commencing January 1998 through 2001 ($ million dollars):

	1998	1999	2000	2001	Total
SDG&E	$32	$32	$32	$32	$128
SCE	$90	$90	$90	$50	$320
PG&E	$106	$106	$106	$106	$424
Total	$228	$228	$228	$188	$872

Article 8, Section 385 (a) directs each local publicly owned electric utility to establish a non-bypassable, usage based charge on local distribution service of not less than the lowest expenditure level of the three largest IOUs on a percent of revenue basis, calculated using the utility's total revenue requirement for the year ended December 31, 1994, and IOU total annual expenditures described above under section 381 (approximately 3 percent).

[104] CPUC Decision D.0312062 directs IOUs recover authorized procurement-related energy efficiency [costs] through its existing non-bypassable Public Purpose Programs Charge (PPPC), which applies to all IOU retail customers. Additionally, CPUC D.03-12-062 directs that incremental procurement

Table C-15 shows projected procurement costs for utility energy efficiency programs for the years 2004 through 2008 ($ millions):

Table C-15 IOU Supply Portfolio of Electric Energy Efficiency Procurement

Utility	2004	2005	2006	2007	2008	Total
PG&E	25	50	50	75	100	300
SCE	60	60	60	60	60	300
SDG&E	25	25	25	25	25	125
Total	**110**	**135**	**135**	**160**	**185**	**725**

Table C-16 shows the effect of combining the procurement budget with the budget for electric energy efficiency programs directed under the Public Goods Charge (PGC) funds for 2004 and 2005 ($ millions). This increases the total electric energy efficiency budget for 2004-2005 by $245 million, bringing the total to more than $760 million.

Table C-16 IOU Combined Electric Energy Efficiency Budgets 2004-2005

	PGC Budget	Procurement Budget	Total Budget
PG&E	258	75	333
SCE	183	120	303
SDG&E	77	50	127
Total	**518**	**245**	**763**

Current Energy Efficiency Program Funding

- $763 million was allocated to 2004-2005 electric energy efficiency programs, an increase of $245 million (43 percent) over statutory levels
- The 2006 – 2008 funding cycle was approved at just under $2 billion, of which approximately $1.5 billion is for electric energy efficiency, with the balance for natural gas.

Current Water Efficiency Program Funding

- In 2002 voters approved Proposition 50, which provides $180 million for water use efficiency programs in the years 2003 – 2007[105]. Proposition 50 annual

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energy efficiency costs be subject to recovery though a non-bypassable charge to all customers and orders IOUs to establish the Procurement Energy Efficiency and Balancing Account (PEEBA) to track costs and revenues.

[105] Proposition 50 Chapter 7 provides $180 million for water use efficiency programs per year as follows: Urban water use efficiency $60 million; Agricultural water use efficiency $60 million; Water

funding for water efficiency is estimated at $36 million (actual program funds provided water agencies is reported to be an average of approximately $30 million per year[106]).

- Funding for water efficiency programs also comes from several other sources, including the implementing water agency, the state's General Fund, federal funds, and general obligation bonds. While these sources add to the available funds, the total is significantly less than that committed to energy efficiency programs.
- Funding has fallen below commitments made in 2000 through the CALFED Record of Decisions, Stage 1 2000-2007. By 2003 investments lagged by $235 million[107].

Integrated Resource Planning

Currently, water efficiency programs receive no credit for, and planners do not quantify, the large energy savings associated with water saving measures that are implemented. Additionally, until energy efficiency regulation and policy are changed, energy utilities cannot include or target these significant energy-efficiency gains. Neither water nor energy efficiency program planners address or target these potential efficiency gains, and a significant gap exists in statewide water and energy resource planning.

Water, wastewater, and energy efficiency program planners acknowledge the importance of comprehensive resource management. Water efficiency programs are based on the same cost-benefit methodology as energy efficiency programs and reference the Standard Practice Manual.[108] This common methodology recognizes the importance of clearly understanding the following four cost-effectiveness perspectives:

1. Water, wastewater or energy program participants
2. The water, wastewater or energy utility
3. The water, wastewater or energy supply system
4. Society

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recycling $60,000. The Bond law was passed in November 2002, and the funding will be allocated through 2007 (five years). Proposition 13 also had funding for water use efficiency but in form of loan. DWR Water Use Efficiency Office is funded partially through the general fund; annual budget less than $1 million. In addition to Statewide funding, local agencies also budget for water use efficiency programs.

[106] See footnote 72, Proceeding Minutes page 23.

[107] Department of Water Resources 2005 Water Plan Update, Volume 2, page 22-2.

[108] "A Guide to Customer Incentives for Water Conservation" Prepared by Barakat and Chamberlain for CUWA, CUWCC, and US EPA, February 1994 (EPA # 230R94001).

However, water, wastewater, and energy efficiency cost-benefit valuation is performed from the utility and, in the best cases, the electric supply system ***or*** the water supply system ***or*** the wastewater collection system perspective (See 2 or 3 above). Ultimately the suboptimal affects of this discrete or isolated water, wastewater, and energy resource management is borne by the consumer who must pay the water, the wastewater, and the energy utility bills.

Under the broader societal perspective, transfer payments between the water utility and participating customers are canceled out; also eliminated are transfer payments among the water utility and other utilities. The costs that are avoided by the electric, gas, water, or wastewater utilities are viewed as societal benefits, and any additional costs that are incurred by these utilities as a result of a water efficiency program are societal costs. Drawing the boundary around the entire water use cycle and including all end users and affected utilities facilitates this societal valuation.

Analysis contained in this appendix has demonstrated that the state's water, wastewater and energy resources are inextricably entwined. Incomplete accounting understates the resource value of water use efficiency. Integrated resource planning of water, wastewater and energy must be performed from *society's* perspective and answer the question, "What mix of water and energy efficiency measures will create the greatest return on the combined ratepayer investment?"

An integrated water-energy societal total resource cost valuation would include the avoided marginal cost of water and wastewater treatment, related environmental externalities, and the associated marginal cost of energy (kWh), capacity (kW), transmission, distribution (including line losses), and environmental externalities. Environmental externalities related to avoiding water and energy use need to be itemized (to remove potential double-counting) and combined to reflect composite environmental impacts.

With a more complete avoided cost-based justification, improved cost-benefit ratios and corollary increased program funding, water-efficiency program market penetration could significantly increase. Integrated water and energy demand-side management would increase both water and energy efficiency program impacts.

Suggested Research Topics

1. Regional Cold Water Energy Intensity (near-term):

    a. Research and develop regional cold water energy intensities. Adopt proxy values and establish linkage to forecasting climate zones. The information being developed by the University of California, Santa Barbara and the Pacific Institute will help develop a proxy that can be relied upon to develop pilot water-energy programs while more detailed studies are being conducted. In particular, while studies of urban water

uses indicate that significant energy can be saved by reducing water consumption, the drivers for these opportunities are not well understood. A comprehensive inventory, characterization, and assessment of the primary types of water-related energy consumption by type of water source, system, function, and end use will eventually be needed to develop the detailed methodologies upon which cost-effective programs can be based. Water-related energy consumption can then be mapped from its source through various categories of end use to develop a comprehensive understanding of the points and relative magnitudes of energy consumption along the water supply chain, and the types of systems, processes, equipment, and measures that could reduce water and energy consumption at these points.

b. For existing cold ,water measures develop base case unit energy consumption (UEC), high-efficiency (HE) UEC, Base and HE Peak watt and demand savings, volume sensitive installed measure costs, and expected useful life values.
c. Identify opportunities for participating in demand response programs.
d. Identify and evaluate new cold water measures targeted to create resource value specifically suited to integrated water-energy resource planning not previously addressed under the discrete/isolated water/energy resource management regime.
e. For cold water measures found to be viable under item d., above, develop planning data identified for existing cold water measures.
f. Incorporate research elements (steps a. through d., above) into the Database for Energy Efficiency Resources (DEER) for use by energy efficiency program planners consistent with program planning protocols enunciated in CPUC Rulemaking 01-08-028, Decision 05-04-051.

2. Pilot Projects that Document and Quantify the State's Primary Water-Energy Interdependencies (longer-term):

    a. Select water utilities that collectively represent most of the primary types of water-energy interdependencies in California to include in the pilot. Several water utilities have already indicated interest in participating in such a pilot. These include the Metropolitan Water District (MWD), Inland Empire Utilities Agency (IEUA), the Los Angeles Department of Water and Power (LADWP), Palo Alto Utilities, and Sonoma County Water Agency.
    b. Conduct pilot projects to document the specific relationships.
    c. Inform and adjust proxy values developed above.

3. Seasonal Demand Shifting

    a. In Southern California, groundwater pumping uses approximately 30 percent of the energy required to import water from Northern

California. Groundwater aquifer source production and recharge requirements are fixed and finite. During periods of seasonal peak energy demand water agencies might rely on groundwater sources and recharge the aquifers using imported water months later in the off-peak season. In this manner ground water storage capacities could be used to encourage large-scale and long-term seasonal peak demand shifting.

b. Identify groundwater aquifers where groundwater pumping and recharge is being performed by water agencies.
c. Identify groundwater aquifers that are not currently being tapped for groundwater pumping.
d. Assess the operational feasibility and associated costs and benefits to encourage the seasonal demand shifting described above (item a.).

4. Conveyance-Related Peak Demand Reduction (State Water Project and other systems)

    a. Water agencies undertake projects to increase pumping and storage capacities based upon the given agency's operational cost-benefit perspective. Assess and report incremental cost-effective measures that can be implemented to increase pumping capacities and storage to reduce peak energy demands that are cost-effective, based upon a more comprehensive societal cost-benefit evaluation.
    b. Evaluate opportunities to reduce peak demand through the coordinated operation of federal and state water projects.

APPENDIX D: EXCERPT FROM CALIFORNIA WATER PLAN UPDATE 2005

VOLUME 1, STRATEGIC PLAN, CHAPTER 2, A FRAMEWORK FOR ACTION

Sustaining Our Water Resources

Fundamental Lessons

The Framework for Action embodies the following fundamental lessons, learned by California's water community through the experience of recent decades.

- The practice of water conservation and recycling in California has grown dramatically and must continue as a fundamental strategy for all regions and individual water users in California. The cumulative effect of each decision to use water more efficiently has an enormous impact on future water supplies and water quality.
- California must protect the quality of its water and use available supplies with great efficiency because water will always be a precious resource.
- Science and technology are providing new insights into threats to our watersheds, including our waterways and groundwater basins. California must use this knowledge to take protective actions and manage water in ways that protect and restore the environment.
- Sustainable development and water use foster a strong economy, protect public health and the environment, and enhance our quality of life. Sustainable development relies on the full consideration of social, economic, and environmental issues in policy- and decision-making. Sustainable water use assures that we develop and manage our water and related resources in a way that meets the needs of the present while protecting our environment and assuring the ability to meet the needs of the future.
- Solutions to California's water management issues are best planned and carried out on a regional basis. Hydrological, demographic, geopolitical, socioeconomic, and other differences among California's regions demand that the mix of water management strategies be suited to meet each region's needs for the long term.
- California needs additional groundwater and surface water storage capacity. Storage gives water managers tremendous flexibility to meet multiple needs and provide vital reserves in drier years.

Foundational Actions

To ensure that our water resource use is sustainable, water management at all levels – State, federal, regional, and local - must achieve these three foundational actions:

1. Use water efficiently.
2. Protect water quality.
3. Support environmental stewardship.

A number of resource management strategies that can be used to accomplish the foundational actions are listed in the following sections and described in more detail in Volume 2 Resource Management Strategies.

Use Water Efficiently

To minimize the impacts of water management on California's natural environment and ensure that our state continues to have the water supplies it needs, Californians must use water efficiently to get maximum utility from existing supplies. Californians are already leaders in water use efficiency measures such as conservation and recycling. Because competition for California's limited water resources is growing, we must continue these efforts and be innovative in our pursuit of efficiency. Water use efficiency will continue to be a primary way that we meet increased demand. In the future, we must broaden our definition of efficient water use to include other ways of getting the most utility out of our groundwater and surface water resources and water management systems:

- Increase levels of urban and agricultural water use efficiency.
- Increase recycled municipal water and expand its uses.
- Reoperate water facilities to improve their operation and efficiency.
- Facilitate environmentally, economically, and socially sound transfers.
- Reduce and eliminate groundwater overdraft.

As California's population grows from 36.5 million to a projected 48 million in 2030, there is bound to be an effect on California's environment. By wringing every bit of utility from every drop of water, Californians can stretch water supplies and help ensure continued economic and environmental health.

Protect Water Quality

California must also protect and improve water quality to safeguard public and environmental health and secure the state's water supplies for their intended uses. Water supply and water quality are inseparable in water management. While implementing projects to reduce water demand or to augment supply, water managers must employ methods and strategies that protect and improve water quality:

- Protect surface waters and aquifers from contamination.
- Explore new treatment technologies for drinking water and groundwater remediation.

- Match water quality to its intended uses.
- Improve management of urban and agricultural runoff.
- Improve watershed management.

Support Environmental Stewardship

To ensure sustainability, California must also manage water in ways that protect and restore the environment. Water is a vital natural resource for people and the environment, so water management activities must occur in the context of resource management and environmental protection. Water development in California has a rich history of conflict, at times pitting water supply projects against ecosystem protection. Water supplies and the environment must both be considered together. Water managers must support environmental stewardship as part of their management responsibilities. As managers develop and deliver reliable water supplies, environmental stewardship can be incorporated in many ways:

- Integrate ecosystem restoration with water planning and land use planning.
- Restore and maintain the structure and function of aquatic ecosystems.
- Minimize the alteration of ecosystems by water management actions.
- Improve watershed management.
- Protect public trust resources.
- Integrate flood management with water supply management.

Recommendations

California Water Plan Update 2005 provides recommendations for the next 25 years. These recommendations are directed at decision-makers throughout the state (referred to as California), the executive and legislative branches of State government, and DWR and other State agencies. (See Chapter 5 Implementation Plan for details.)

1. California needs to invest in reliable, high quality, sustainable, and affordable water conservation, efficient water management, and development of water supplies to protect public health, and to maintain and improve California's economy, environment, and standard of living.

2. State government must provide incentives and assist regional and local agencies and governments and private utilities to prepare integrated resource and drought contingency plans on a watershed basis; to diversify their regional resource management strategies; and to empower them to implement their plans.

3. State government must lead an effort with local agencies and governments to inventory, evaluate, and propose management strategies to remediate the causes and effects of contaminants on surface and groundwater quality.

4. California needs to rehabilitate and maintain its aging water infrastructure, especially drinking water and sewage treatment facilities, operated by State, federal, and local entities.

5. State government must continue to provide leadership for the CALFED Bay-Delta Program to ensure continued and balanced progress on greater water supply reliability, water quality, ecosystem restoration, and levee system integrity.

6. State government needs to take the lead in water planning and management activities that: (a) regions cannot accomplish on their own, (b) the State can do more efficiently, (c) involve interregional, interstate, or international issues, or (d) have broad public benefits.

7. California needs to define and articulate the respective roles, authorities, and responsibilities of State, federal, and local agencies and governments responsible for water.

8. California needs to develop broad and realistic funding strategies that define the role of public investments for water and other water-related resource needs over the next quarter century.

9. State government should invest in research and development to help local agencies and governments implement promising water technologies more cost effectively.

APPENDIX E: A WATER-ENERGY ROADMAP

Recommendations of the Water-Energy Relationship Working Group

Presently, water and energy utilities seek to separately optimize their respective resource portfolios. Since energy is typically their second largest cost,[109] water utilities already proactively seek opportunities to reduce energy consumption and increase energy production to reduce the net cost of their water supplies. However, the search for opportunities typically does not extend beyond their own systems and facilities. This is more a significant opportunity than a problem.

Stakeholder input for this staff paper indicates that the greatest potential for positively affecting the state's energy circumstance is beyond current best practices. Specifically, the primary opportunity is in the integrated value of water, energy, and externalities - like societal value - embedded in a unit of saved water. The incremental benefit of these integrated values can be realized by arranging the systems and operations of both the state's water and energy utilities around this holistic valuation approach.

For example, the state's single largest consumer of energy, the State Water Project (SWP), already strives to maximize off-peak and minimize on-peak pumping. However, if the goal were instead to minimize total and peak water-related energy consumption throughout the state, what options might be considered that would otherwise remain unconsidered? Below is a sample of the types of opportunities that could be possible if the planning perspective were broadened to include the optimization of water and energy resources statewide.

- Shift water pumping to off- and partial-peak time periods. Both DWR and the State Water Contractors (SWC) – 29 water agencies that purchase water from the SWP -- note that the SWP is designed to deliver water 24 hours a day, 365 days a year. Purchasers of SWP water need to take delivery when it comes down the aqueduct. Additional storage at strategic points along the aqueduct, whether owned by SWP or any of its customers, could increase operating flexibility and allow additional shifting of both SWP and SWC pumping loads to partial-and off-peak periods.[110]

- Shift water pumping to non-summer periods. Some water agencies in Southern California already rely heavily on groundwater pumping during the

[109] Salaries are usually first.
[110] Any increase in storage increases operational flexibility. This can be accomplished by oversizing aqueducts and canals, off-stream storage, and pipelines. SWP agricultural customers' systems are presently optimized for 24-hour deliveries. With proper incentives, it may be possible to modify these agricultural customers' systems to increase flexibility in SWP deliveries.

summer, and recharge their wells with imported SWP water during other times of the year. This groundwater production and recharge could be coordinated to create seasonal load-shifting.[111]

- Increase use of recycled water. While use of recycled water has nearly tripled since 1970, it still accounts for a very small percentage of the state's water supplies.[112] At a minimum, recycled water should be used wherever possible for landscape irrigation, though the high cost of dual distribution networks has been a major barrier.[113] When viewed from a societal perspective, significant investment in programs to reduce landscape irrigation is warranted on the basis of their energy benefits alone.

- Capture energy in water systems. Water utilities purchase significant amounts of energy to transport water though their systems. There are opportunities to recapture some of this energy through in-conduit turbines. The effect of this in-conduit hydropower production would be to decrease a water utility's net energy requirements. While opportunities exist to capture this energy, there are few incentives (and many disincentives) for development. Viewed on a holistic basis, the efficient utilization of energy within an existing pipeline or conduit would be viewed as an efficiency retrofit that qualifies for funding support by energy utilities.[114]

- Reduce energy for water pumping. Oversizing and/or lining pipelines can reduce friction and the amount of energy needed to transport water.

- Reduce energy for treatment. Both potable and wastewater systems could be reconfigured to incorporate storage, allowing treatment to be deferred to off-peak periods.

In addition to opportunities for reducing and shifting water utilities' energy consumption, stakeholders identified an important new opportunity – saving energy by saving water. When a unit of water is saved, so too is the energy required to convey, treat, deliver, and safely dispose of that unit of water.

In order to employ this value in designing cost-effective programs, this water ***energy intensity*** must take into account all of the steps in the water cycle. The energy

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[111] The state's highest electric demand is on hot summer days. If significant water activities could be shifted to other months, the state may need to build less generation and transmission capacity. In addition, electric reliability would be increased, and the adverse public health, safety, and economic impacts of rotating outages avoided.

[112] *California Water Plan Update* 2005, public review draft, April 2005.

[113] During summer months, as much as 50-70 percent of residential water use in Central and Southern California is for landscape irrigation.

[114] In-conduit hydropower does not presently qualify as an energy efficiency retrofit for purposes of energy utilities' programs. While in-conduit hydropower is RPS-eligible and could qualify for supplemental energy payments (SEPs), it would not be feasible to develop mini- and micro-hydro under the same rules as utility-scale generation.

intensity of cold-water energy savings is presently not considered in water or energy efficiency program planning. When a saved unit of water is valued from a societal cost perspective, significant energy-efficiency, embedded in water efficiency, is clear. The following example shows the electric energy resource value of just one water efficiency measure, BMP14[115]:

> An ultra-low-flow toilet saves 11,340 gallons of water per year and has a service life of 25 years. This results in potable cold-water energy savings of 91 kilowatt hours (kWh) per year, or 2,275 kWh over its useful life. The present value of electricity's avoided cost is $141. In 2004, water utility programs installed 1.8 million ultra-low-flow toilets in California residences, resulting in cold water savings of 60 million kWh per year, or 1.5 billion kWh over the program's life. The present avoided cost value through this single BMP is $119 million[116].

This simple analysis shows how energy can be saved by saving water. However, energy utilities are not currently authorized to invest in cold water savings. This raises some important questions:

- How much water or energy could be saved with existing technology, without basing their cost-effectiveness upon a single resource like the avoided cost of water or electricity, natural gas, or diesel?

- What incremental energy benefits would be realized if saved water were valued on a societal basis, and energy utilities were allowed to participate in programs that save energy by saving water?

Regarding a comprehensive statewide water and energy program:

- How can programs and incentives be structured to both encourage collaboration across utility systems and boundaries and allow energy utilities to share the costs of water conservation and efficiency programs (to access water savings not deemed cost-effective on a single utility resource cost test)?

The following table describes some actions that could facilitate a statewide shift toward integrating the water and energy resource planning and management needed to achieve incremental societal benefits.

[115] See discussion of water conservation and efficiency "best management practices" (BMPs) in Appendix C.
[116] See Appendix C for full discussion of this issue and information source references.

ENERGY OBJECTIVE	APPROACH	OPTIONS
Optimize the state's water and energy resources & assets on an integrated basis	Build policy framework & infrastructure	1. Identify synergistic benefits that make business sense to both water & energy stakeholders. 2. Revise both water & energy utilities' investment criteria to incorporate a societal perspective. 3. Adjust resource pricing methodologies to reflect total societal values. 4. Authorize energy utilities to invest in programs for cold water savings. 5. Structure funding & incentives to attain targeted responses. 6. Provide low-interest loans & grants for incremental water infrastructure that produce benefits to the electric grid. 7. Create a joint agency task force to establish protocols for sharing costs, benefits and responsibilities among multiple stakeholders subject to different jurisdictional rules and regulations. 8. Coordinate water and energy capital programs to maximize infrastructure investments for benefit of both resources.
Increase energy supplies	Support development of additional hydropower capacity	1. Resolve conflicts with FERC relicensing process. 2. Modify Renewable Portfolio Standards to include all new and increased hydropower capacity. 3. Provide access to Supplemental Energy Payments. 4. Establish incentives for re-powering for incremental pumped storage capacity.[117] 5. Allow in-conduit hydropower to qualify for funding as an energy recovery facility, qualified as an energy efficiency retrofit.
	Remove disincentives to energy self-sufficiency	1. Allow water utilities to wheel self-produced power to themselves, anywhere on their systems. 2. Streamline the interconnection process and reduce costs. 3. Remove net metering caps.
	Encourage production of excess power	1. Provide technical & funding support for development of renewable resources & distributed generation. 2. Encourage partnering between water & energy utilities in power development. 3. Establish long-term power purchase agreement for such excess production that exceeds bulk wholesale markets and

[117] Hetch Hetchy implemented system improvements that increased peak hydropower capacity by 48 MW at a capital cost of $8 million, 83 percent less than the cost of installing a new unit of comparable capacity.

ENERGY OBJECTIVE	APPROACH	OPTIONS
		assures payments that support project financing. 4. Provide a ready market for purchasing any over-production of power (e.g., require investor-owned utilities to include in their energy supply portfolios).
Increase energy efficiency and demand side management	Help water utilities develop & implement comprehensive energy management	Provide technical, funding & other support.
	Reduce peak energy consumption (seasonal & time-of-use)	Increase system & operating flexibility (e.g., increase capacity for pumping groundwater during summer, deferring water imports to fall and winter).
	Establish incentives for shifting seasonal use	Compensate water utilities for deferring water imports from summer to fall.[118]
Increase operating flexibility	Maximize ancillary services benefits of the state's hydropower resources	1. Increase pump storage capacity. 2. Use hydro to shape wind & other intermittent resources (e.g., solar).
	Increase storage	Support development of new and incremental storage wherever possible.[119]
Increase water conservation & efficiency	Increase investments that attain statewide energy benefits	1. Incorporate a societal perspective into water utilities' investment criteria. 2. Allow energy utilities to invest in water system improvements that attain benefits for energy ratepayers. 3 Create a Public Goods Charge equivalent for water utilities.

A Conceptual Road Map

Following is a conceptual road map for a five-year program structured to achieve the above objectives. The plan considers a three-phase approach:

Phase 1 – Policy Framework and Infrastructure
Phase 2 – Pilot Programs
Phase 3 – Implementation

The process of building the policy framework and infrastructure needed to support a major policy shift of this kind would begin in *Phase 1*. *Phase 2* would be triggered by adoption of interim policies and pilot programs by energy utilities, and their regulator(s), in recognition of the energy value of saved water. *Phase 3* would begin with adoption of permanent policies and programs by energy utilities and their regulator(s) that will invest in saving water to save energy.

[118] Incentives already exist to encourage shifting loads from on-peak to partial- and off-peak periods.
[119] Water remains the most effective means of storing energy.

The work in each phase is generally described below.

Phase 1 – Policy Framework and Infrastructure [8-12 months]

During the initial phase, three distinct activities would proceed concurrently:

- Task 1: Increase access to existing energy programs and resources by water and wastewater utilities.

- Task 2: Develop a policy roadmap for statewide integrated water and energy planning and management.

- Task 3: Conduct studies of California's water-energy relationships.

Activities included in each task could include, but are not limited to, the following:

Task 1: Increase access by water and wastewater utilities to existing energy programs and resources. Energy utilities already offer programs where water utilities can participate. These include traditional energy efficiency programs such as retrofits of lighting and HVAC and programs for increasing the efficiency of pumps and motors. In addition, the state's investor-owned utilities (IOU) offer energy-performance contracts (EPCs) that provide customized cash incentives for projects that demonstrate real energy savings.

The following tasks are designed to increase access to existing programs and resources, identify additional resources, and facilitate identification of opportunities for attaining incremental benefits through increased collaboration, and, potentially, the joint operation of multi-utilities' systems, resources, and assets.

1.1 Develop a clearinghouse of water-related energy information for water professionals and others concerned about energy and water use in California. The clearinghouse should include the leading references and studies that highlight energy best practices for water utilities; creative approaches to system design and operations that provide operating flexibility to moderate peak energy consumption; opportunities to become energy self-sufficient; and sources of technical, funding and other types of support.

1.2 Develop a pilot assistance program for water utilities to help individual water agencies integrate comprehensive energy planning and management into their activities.

1.2.1 Establish the baseline of current practices. Provide direct and active technical assistance for best practices for reducing energy consumption by water systems and processes. Encode these best practices into benchmarking tools and make them available to practitioners, enabling them to compare their current practices with what is possible. Develop a clearinghouse of information on a range

from current to best practices. Establish measurement and evaluation protocols to verify savings and share lessons learned.

1.2.2 Provide incentives for incremental and/or joint infrastructure improvements that reduce total and peak energy requirements for water transport and processing. These incremental facilities would likely include storage (reservoirs, groundwater wells, and oversized pipelines) that both increases system flexibility and facilitates time-of-use (TOU) and/or seasonal load shifting.

1.2.3 Identify long-term funding opportunities for both ongoing existing programs and for funding retrofits that exceed single utility resource cost-effectiveness tests.[120]

1.2.4 Assist in identifying opportunities for peak-load reductions and seasonal load shifting.

1.2.5 Provide technical and funding assistance in identifying and implementing self-generation opportunities, especially renewable resources and emerging technologies.

1.2.6 Facilitate opportunities for collaborating with local energy distribution companies on all aspects of energy management and energy self-sufficiency, including strategies to meet projected load growth.

Depending upon the results of the pilot, successful programs could be quickly ramped up to provide assistance to water agencies statewide.

Task 2: Develop a policy roadmap for statewide integrated water and energy planning and management. A policy shift of this magnitude requires thoughtful consideration of the barriers and hurdles that need to be overcome before successful implementation. A policy roadmap identifying key changes to laws and regulations that would help facilitate the shift would be very beneficial when embarking upon this effort. The types of activities within this task could include:

2.1 Establish a statewide multi-agency Water-Energy Task Force. This task force would provide consistent, long-term leadership, policy direction, and technical and resource support for a comprehensive statewide water-energy program. The Water-Energy Task Force would include staff from the Energy Commission, Department of Water Resources, California Public Utilities Commission, Air Resources Board, State Water Resources Control Board, and the California Department of Health Services.

The goal of the task force would be to achieve the benefits of *statewide integrated planning and management of the state's water and energy resources*. Specific tasks include the following:

[120] Long-term funding was identified as an important factor in gaining support from water utilities.

- Collaboratively build a knowledge base of water and energy interdependencies. Investigate beneficial statewide integrated water and energy planning and management practices and recommend policies, programs, and funding for successful programs.

- Expand the Water-Energy Relationship (WER) Working Group created through this process to include strong participation by all key stakeholder groups needed for successful implementation of the program. The WER Working Group will provide technical advice to the Water-Energy Task Force.

- Designate a Water-Energy Liaison at the Energy Commission. This person or group would be responsible for coordinating policy, research, and programmatic efforts within the Energy Commission and act as liaison to the Water-Energy Task Force, other state agencies, local jurisdictions, and water, wastewater, and energy utilities. Similar people or groups should be identified at other agencies on the Task Force.

- Collaborate with other parties and entities with compatible goals. These include DWR's Office of Water Use Efficiency, the Recycling Task Force, and the Desalination Task Force.

- Develop a roadmap that establishes goals for increasing water efficiency and demand-side management. Among other things, the roadmap should prioritize investments in programs and measures that have the highest resource value and impact. In recognizing that every unit of water saved allows displacement of higher-energy intensity water supplies, high priority should be assigned to reductions in agricultural water use and urban landscape irrigation, both residential and commercial.

- Charge the Water-Energy Task Force with monitoring technology changes that affect the energy intensity of the water cycle, and identify potentially feasible and cost-effective applications.[121] A mechanism should be established to continually identify and incorporate new technologies wherever beneficial and feasible.

2.2 *Build the policy framework and infrastructure.* The concept that there are statewide benefits from "saving water to save energy" needs to be emphasized and regularly underscored*. Energy Report* findings and recommendations should be presented to the CPUC, water and energy utilities, key water and energy

[121] For example, new tunneling equipment and techniques may one day make it possible to drill through mountains instead of transporting water over mountains, significantly reducing energy used for water pumping. In addition, improvements in desalination and other water supply development techniques may become more cost-effective than transporting water from Northern California to Southern California. Further, technologies such as cloud seeding may become more successful in producing local supplies that could reduce Southern California's need for water imports.

policymakers, and other key stakeholders. The bases for computing potential benefits needs to be widely and clearly understood.

Policies, procedures, business processes, analytical methods, investment criteria, and decision making tools all need to be adjusted to support a policy and planning shift of this magnitude. To support this shift, the importance of the state's water-energy relationship needs to be better understood. Preliminary studies show the complexities of the water supply balance and cycle, and geographic, source, end user and other diversities – all of which must be documented, quantified, and modeled to assure that programs and strategies achieve their intended results. Thereafter, policies, rules, regulations, protocols, methodologies, programs, and funding need to be brought into alignment.

- Establish a valuation methodology for the societal value of water. We are just beginning to understand the water-energy relationship. Preliminary studies of the water supply-use-disposal cycle and overall water supply balance show distinctly different energy intensities of water in various regions of the state, depending upon climate, topography, and water storage/recovery/delivery options and methods. In addition, different uses have different energy intensities. A valuation methodology is needed to capture these diversities in a manner that will help planners prioritize their investments.[122]

- Leverage developmental work already in progress by others, including the U.S. Department of Energy National Laboratories' Water-Energy Nexus Program, Pacific Institute, California Urban Water Conservation Council, and the Irrigation Training and Research Center. Collaborate with these (and other) entities, to:

    - Inventory, characterize, and measure California's types of water and energy interdependencies.

    - Develop pilot programs to test tools and methodologies for evaluating tradeoffs among these interdependencies.

    - Develop analytical models for policymakers, regulators, utilities, and other key stakeholders in developing cost effective joint water and energy programs.

- Facilitate joint investment to attain societal benefits. As opportunities are identified that could produce incremental energy benefits but are not deemed

[122] For example, while it may be possible to increase total groundwater capacity in Southern California, unique geological characteristics create uncertainties as to both ultimate capacity (groundwater doesn't behave predictably) and impacts on production capacity of other wells in the vicinity. Similarly, displacing SWP imports with increased seawater desalination in Southern California may not produce a net benefit; nor would over-pumping of groundwater supplies and reducing drought reserves be desirable. All of the interdependencies – water to energy, energy to water, and water to water -- need to be evaluated to determine how best to attain positive net benefits.

cost-effective on a single utility resource cost test, mechanisms are needed that facilitate joint investment to attain those incremental benefits.

- Incorporate a societal valuation approach in both water and energy utilities' resource pricing methodologies, water and energy efficiency program portfolios, and investment criteria.

- To facilitate early results, establish a proxy for the societal value while a detailed methodology is developed.

- Establish a water resource loading order that incorporates the societal value of an avoided unit of water consumption and that mirrors the preferred energy resource loading order in the Joint Agency Energy Action Plan for energy.[123]

- Establish a public goods charge equivalent for public purpose water conservation and efficiency programs.

- Provide incentives for water, wastewater, and energy utilities to optimize their joint resources beyond traditional discrete single utility service boundaries (water or energy).[124]

- Require the state's energy and water planners to collaborate on plans and strategies to reduce net water sector energy consumption and to meet projected energy load growth.

2.3 Identify changes to existing laws and regulations. Examples of some proposed changes are provided in the table of potential actions on pp. 4-5.

2.4 Request that DWR provide input to the IEPR with respect to projected energy load growth in the water sector and potential energy impacts of drought risk mitigation measures. Similarly, request Energy Commission's participation in DWR's Water Plan Update process to provide assumptions as to energy supply availability and price forecasts.[125] Energy Commission and DWR should also synchronize planning assumptions for dry, wet and average hydrology years, as well as

[123] The California Water Plan Update 2005 already identifies a prioritized resource strategy. In order to attain results that optimize the state's water and energy resources on a joint basis, societal values should also be considered in the resource loading order. For example, least-cost water supply options at low electricity prices (e.g., desalination and water transfers) may become expensive when electricity prices are high. Since high electricity prices typically coincide with electricity supply shortages, water resource planning that does not consider energy impacts during times of shortage can create electric reliability risks that affect all California ratepayers. Integrated planning of water and energy resources provides the policy perspective needed to develop contingency plans and strategies for mitigating these types of risks.

[124] For example, the SWP could work with the water agencies that take water from the aqueduct to identify incremental infrastructure and changes to operations that can shift more water pumping to off-peak periods and/or non-summer months.

[125] This could result in a water supply equivalent of the state Energy Action Plan's resource load order.

assumptions as to the duration and magnitude of a multi-year drought for contingency planning purposes.

2.5 Expand the 14 water conservation best management practices (BMPs) to include new measures that meet the broader goals of statewide integrated water and energy planning and management.[126] Prioritize investments in BMPs in accordance with cost-effectiveness from a societal perspective.

2.6 Resurrect long-term purchase commitments (e.g., "standard offer contracts") that provide a ready market for excess power produced by water agencies after meeting all of their own energy requirements. One option might be to merely include such default purchase mechanisms in investor-owned utilities' procurement baselines.

2.7 Increase collaboration among state agencies to assure a consistent policy perspective. Unintended consequences result when multiple regulators seek to discharge their separate responsibilities in absence of a consistent policy framework. For example, while the state is encouraging increased energy production, the Department of Fish and Game restricted operational flows at Silverwood, a man-made reservoir, to protect non-native fish. The WER Working Group identified a need for consistent policy in which state agencies collaborate regularly to assure that energy, water and environmental benefits are continually balanced.

Task 3: Conduct studies of California's water-energy relationships. There is a near-term opportunity to access California ratepayer funds to support the policy shift to statewide integrated water and energy planning and management. Specifically, the state's investor-owned utilities are challenged to attain the targeted energy efficiency goals established by the CPUC for the 2006-2008 round of ratepayer investments. The opportunity to save water to save energy has significant promise to deliver, and potentially to exceed, system benefits targeted by the CPUC. In fact, water-energy programs may well represent the most promising opportunity for "second generation" energy efficiency measures.

The purpose of this task is to establish the foundation for an interim water-energy program that will demonstrate the expected benefits of statewide integrated water and energy resource management, prior to establishing permanent programs. The following work will need to be accomplished to support design of one or more interim programs.

3.1 Establish an interim methodology and proxy for the societal value of a unit of water saved. Design of cost effective programs requires computation of the societal value of a saved unit of water. The computation needs to be performed over the

[126] See Appendix C for a discussion about water conservation BMPs.

entire water use cycle (i.e., the total costs of water, externalities and energy incurred during the entire life of a unit of water[127]).

Ultimately, a comprehensive methodology is needed that recognizes the diversity of water supplies, treatment processes, types of end use, and other factors. The number and complexity of variables will need to be analyzed to determine which are most significant in computing the societal value. In the meantime, a proxy can be employed to allow interim water-energy programs to go forward while detailed studies of the water-energy relationship continue in parallel. There is precedent at the CPUC for utilizing proxies while formal methodologies are being debated and refined.[128]

[Note: The "triple bottom line" concept captures the full spectrum of economic and societal values that today's organizations must address. In developing the proxy, it may be desirable to consider aligning the components of the societal value of water with this evolving concept that is gaining increased acceptance.]

3.2 Inventory needs. Prior to designing the studies, a needs assessment should be conducted to inventory the spectrum of primary water-energy relationships in California, and the current body of data, models, tools, policies, programs, practices, funding, legislation and regulations. Water-related energy consumption will be benchmarked by type of water system, function, and end use. Water-related energy consumption will then be mapped from source through various categories of end use to develop a comprehensive understanding of the points and relative magnitudes of energy consumption along the supply chain, and the types of systems, processes, equipment and measures that could reduce energy consumption at these points.

3.3 Conduct detailed studies. The final task under Phase 1 is to conduct detailed studies of California's water-energy interdependencies and to integrate these data into analytical models and tools that can help both water and energy utilities develop cost-effective joint water-energy programs. The scope of these studies will include establishing baseline water use by all sectors and then linking this to the energy baseline. In addition, technologies will be researched for their water and energy savings potential, and the associated environmental benefits.

Studies will proceed in parallel with commencement of Phase 2 – Pilot Programs. The Pilot Programs will employ a proxy until more detailed data and methods become available to support adoption of a formal methodology for valuing the energy and societal value of an avoided unit of water. The types of studies needed are described more fully at the end of this appendix.

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[127] Water collection, transmission, treatment, distribution, wastewater treatment, and ultimate disposal or recycling.

[128] In recent years, for example, proxies were established and relied upon by the CPUC for both the market price referent and avoided costs of energy.

Phase 2 – Pilot Programs [12-24 months]

During Phase 2, a proxy will be adopted and applied to develop pilot water-energy programs in which the projected incremental benefits of joint water and energy planning and management can be verified. Concurrently, Phase 1 studies to perfect the data, methods, and tools needed to establish a reliable methodology for supporting development of cost effective programs on an ongoing basis will continue in parallel.

Several water-energy pilot programs are recommended:

- A pilot for investor-owned and municipal utilities that targets specific types of water use reduction to demonstrate and measure the expected economic and reliability benefits to energy ratepayers and the California electric grid. The pilot would employ a proxy for the societal value of each type of water use reduction based on a preliminary methodology, pending completion of further studies and analyses. The scope of such a pilot could include:

    - Direct co-investment by energy utilities in water conservation and efficiency programs with high potential for energy savings. (The Pacific Institute, in its November 2003 study "Waste Not, Want Not: The Potential for Urban Water Conservation in California", estimated a remaining annual potential for cost effective urban water conservation as high as 2 million acre feet (651.7 billion gallons). Assuming a conservative estimate of 5,000 kWhrs/mg[129], this quantity of saved water could reduce energy consumption by 3,258 Gwh per year. This is about 1.8% of the state's total energy consumption.)

[129] Refer Appendix C, Energy Impact Analysis of Existing Water Management Practices. For the sole purpose of illustrating the potential magnitude of impacts, we have assumed a statewide average value of 5,000 kWhrs/mg.

California Urban Water Use in 2000
and the Potential to Improve Efficiency and Conservation

California Urban Water Use by Sector	Current (2000) Water Use (AF/year)	Best Estimate of Conservation (AF/year)	Potential to Reduce Use (%)	Minimum Cost-Effective Conservation (AF/year)
Residential Indoor	2,300,000	893,000	39	893,000
Residential Outdoor	983,000 to 1,900,000 (b)	360,000 to 580,000 (c)	25 to 40	470,000
Commercial/ Institutional	1,850,000	714,000	39	Combined CII: 658,000
Industrial	665,000	260,000	39	(e)
Unaccounted-for Water	695,000	(d)	(d)	(d)
Total	**6,960,000** (+/- 10%)	2,337,000	34	2,020,000

Source: "Waste Not, Want Not: The Potential for Urban Water Conservation in California", The Pacific Institute, November 2003.

- Subsidized investments in incremental water infrastructure that are expected to attain significant energy benefits (e.g., increasing capacity of, or adding new reservoirs, pipelines, and groundwater wells).

- A pilot that investigates the potential incremental benefits attainable by optimizing joint water and energy resource management of the state's largest water utilities on a combined basis. For example, the pilot could investigate incremental water and/or energy infrastructure (water storage, delivery, power production, etc.) that could increase the operating flexibility of combined large water systems (SWP, SWC, CVP and/or the Colorado River System, as well as other large water systems that are now or could become interconnected).

<u>Phase 3 – Implementation</u>
Phase 3 will be defined by completion of most of the detailed studies of the state's water-energy interdependencies, and of the analytical models and tools that employ these data to design cost effective joint water-energy efficiency programs. During Phase 3, proxies for the societal value of saved water will be replaced with permanent methodologies, and long-lived (5-10 years) water-energy programs will be established and funded.

Implementation Challenges

While some opportunities could be accessed now for early results, there are some challenges to implementation of joint investments that attain the incremental energy resource and reliability benefits of fully integrated water and energy resource planning and management.

1. Water and energy utilities are regulated, operated and managed separately. Short of a few programs in which end users can earn energy incentives for reducing consumption of hot water, there presently is little incentive for water, wastewater, and energy utilities to even coordinate their resource planning activities and much less to share investments in programs and infrastructure.

2. Program goals and incentives will need to be aligned. Societal values are derived from reducing or avoiding the buildup of costs along the water cycle. In this case, water and wastewater utilities and their ratepayers will need to make the investments that attain energy resource and reliability values that benefit other ratepayers and the state overall. This presents challenges with respect to equitable sharing of joint program costs. For example:

    - Increasing use of recycled water in Southern California to reduce high-energy water imports from Northern California may well provide a benefit to all water and energy ratepayers.[130] However, the incremental investment in recycled water distribution facilities needs to be made by a local government or wastewater utility that must then seek recovery of its investment. If the costs of such incremental facilities are allocated only to users of that recycled water, the cost of recycled water may far exceed the cost of potable water.

    - During summer months, as much as 50 to 70 percent of residential water use in central and Southern California is for landscape irrigation. When viewed from a societal perspective, significant investments in programs to reduce landscape irrigation are warranted on the basis of the energy benefits alone. However, water utilities' investments are limited to those that benefit their own ratepayers (i.e., not on the basis of benefits that may accrue to the entire water supply chain or to other stakeholders). Further, there presently is no mechanism that allows energy utilities to invest in programs that reduce water use to save energy.

Allocating incentives to the stakeholder(s) who need to make the investment on behalf of all California ratepayers, both water and energy, is not a trivial task.

[130] Water ratepayers benefit by avoiding investments in higher cost water supplies and increasing water supply reliability. Energy ratepayers benefit from associated reductions in energy procurement, as well as by avoiding investments in additional electric infrastructure and by increased electric system reliability.

Additional Needs for Research and Assistance

Integrating water and energy resource management will require additional knowledge in a number of key areas to develop the analytical methods, tools, and data needed to develop and implement cost effective water-energy projects and programs.

Building on Present Knowledge

Considerable work is already being performed in this area. Some current efforts are described in Appendix A.

Additional information is needed to facilitate a statewide policy shift to comprehensive planning and management of the state's water and energy resources. In particular, more accurate information about the nature and magnitude of the state's water and energy relationships -- including the spectrum of opportunities for realizing the synergies of integrated water and energy resource management, the amount of needed investments, and the relative costs vs. benefits of each type of measure – is needed to prioritize investments and develop methods, models, and tools that support cost-effective program design.

The following ***conceptual*** research and development plan describes the primary research activities needed to support the program objectives identified in the table in the first section of this appendix. The plan is structured to allow near- and long-term initiatives to proceed in parallel to provide opportunities for early benefits.

CONCEPTUAL Research and Development Plan

R+D Program Objectives	Near-Term Strategies	Long-Term Strategies
1. Proactively manage water-related energy consumption	Synchronize the state's water & energy planning assumptions and strategies to meet projected energy load growth	Develop comprehensive programs for technical & resource assistance that attain water utilities' energy management best practices
2. Increase understanding of the state's water-energy relationship	Demonstrate primary water-energy interdependencies; develop prototypical values by Forecasting Climate Zones	Inventory, document & quantify the state's primary water-energy interdependencies for input to detailed models & tools
3. Implement statewide integrated water and energy resource management	Develop proxy for interim societal valuation methodology for cold water savings for discussion with CPUC[131], policymakers, other interested stakeholders	Develop data, analytical tools and methodology for computing the societal value of saved water for different water sources, end uses, climate zones, etc. for valuation of societal costs in long-term cold water savings programs
4. Increase water utilities' energy self-sufficiency	Investigate potential for revising existing programs, policies, methods & practices to reduce water utilities' net energy consumption ('net' of power production)	Develop studies, methods, tools & techniques to assist water utilities in becoming energy self-sufficient, and potentially becoming net exporters of power
5. Increase water efficiency and demand-side management	Develop preliminary valuation of existing cold-water efficiency measures	Identify & evaluate new cold-water measures; develop cost-effective programs

Primary research and assistance needs identified to-date are described in more detail below by program objective.

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Objective 1: Proactively manage water-related energy consumption.

1. Establish baseline of current practices. Research "best practices" for reducing energy consumption by water systems and processes. Encode "best practices" into benchmarking tools and make them available to practitioners, enabling them to compare their current practices to what is possible. Populate the "Clearinghouse" with information on the range from current to best practices. Establish measurement and evaluation protocols to verify savings and provide lessons learned.

2. Conduct an assessment of the penetration and adoption of "best energy practices" by water and wastewater utilities, and barriers and hurdles that prevent or restrict adoption, to support development of targeted assistance programs that incorporate workarounds to identified barriers and hurdles.

3. Track and evaluate energy use by function to enable development of targeted measures and retrofits with high benefit potential. For example, a better

[131] CPUC could adopt a proxy for the societal value of cold water savings that would allow pilot programs to go forward in the 2006-2008 energy efficiency funding cycle.

understanding is needed as to how recycled water fits into the water supply portfolio and water balance. While increasingly stringent federal discharge rules are pressing water utilities to upgrade secondary treatment to higher energy intensive tertiary treatment, incremental energy consumption attributable to the higher level of treatment should be offset (at least in part) by using recycled water to displace higher energy intensity water supplies.

4. Continue to monitor and plan for projected changes in energy usage by water systems and treatment processes. Continue to study the projected energy requirements of changed federal water treatment and discharge regulations as these evolve, and develop approaches to help energy and water utilities manage the energy impacts of these changes.

5. Continue to identify and evaluate opportunities to reduce energy consumption in targeted high-use sectors, such as agriculture. Work with interested stakeholders to identify and evaluate opportunities to reduce energy use by the agricultural sector and to conduct various studies. Potential projects might, for example, include tracking energy-use trends associated with changes in crop-planting and harvesting patterns; evaluating impacts of pressurized irrigation systems (drip and spray) on fields now irrigated by gravity; and converting diesel-engine pumps to motor-driven pumps.

6. Evaluate the potential energy impacts of increased water transfer transactions. Little is known about whether changes in conveyance patterns will have a noticeable impact on water-related energy consumption. The Energy Commission could work with water utilities involved in contracting for or providing conveyance services, to first determine the likely extent of such transactions, and make a rough estimate of the magnitude of change in electricity use patterns. If warranted, staff could recommend further study of methods to track such transactions, and determine and prepare for their expected energy impact.

7. Continue studies with AwwaRF and others to reduce energy consumption by desalination technologies, and to coordinate water and energy planning for dry years. Though the WER Staff Paper identified only fairly modest impacts on the electric system from known planned desalination plant development, the number of planned facilities could increase quickly if one or both of two things occur: an extended drought or other scenario that significantly curtails surface water deliveries, and/or a significant decrease in the cost of operating such facilities.

8. Develop a comprehensive program to study groundwater-related energy use. Groundwater is a particularly significant area of study, since use of groundwater storage has potentially significant impacts, both positive and negative, on water-related energy consumption. On one hand, increased groundwater storage provides significant operating flexibility that could allow

more SWP water deliveries to be shifted from summer to fall. On the other hand, over-pumping groundwater basins could increase energy consumption at undesirable times and also reduce critical drought supplies.

Less is known about groundwater than any other water source. This is due to the fact that each groundwater basin is unique, and production characteristics of wells are often interlinked. Further, since use of groundwater is largely unregulated, the actual quantity of energy used for groundwater pumping statewide is undeterminable. The complexities of groundwater warrants a comprehensive monitoring approach that tracks groundwater levels, pump production, electricity use, and other data over multiple years.[132]

9. Assist water utilities in developing less energy intensive water supplies. For example, increased reliance on recycled water to displace need for desalted water.

10. Continue to build on PIER/AwwaRF's Water and Wastewater Technology Roadmap.

Objective 2: Increase understanding of the state's water-energy relationship.

1. Conduct pilots and studies that document and quantify the state's primary water-energy interdependencies. The information being developed by UCSB and Pacific Institute will help develop a proxy that can be relied upon to develop pilot water-energy programs while more detailed studies are being conducted. In particular, while studies of urban water uses indicate significant energy can be saved by reducing water consumption, the drivers for such opportunities are not well understood. A comprehensive inventory, characterization, and assessment of the primary types of water-related energy consumption by type of water

[132] The Irrigation Training and Research Center (ITRC) study on agricultural energy requirements perhaps goes farther than any other, and bases much of its information on real-world geographical information system (GIS) data; but it must make many assumptions concerning average pump lift (groundwater levels), distribution uniformity, surface water availability (timing factor), irrigation type, average drawdown, discharge pressure, and so forth. It uses the real-world results of the pump efficiency tests conducted for the Agricultural Peak Load Reduction Program by the Center for Irrigation Technology, but those data did not include static or pumping water levels and primarily covered only wells in PG&E's territory.

Considerable additional study is needed in order to facilitate detailed modeling of groundwater supplies. The ITRC study also is the result of at least two levels of computer modeling: that by Department of Water Resources to estimate groundwater levels in Northern California and ITRC's own crop water model, which produced the energy use estimates in its groundbreaking study. Much of ITRC's results are based on what can only be described as rough calculated estimates by DWR for Central and Southern California groundwater volumes, which is especially critical in the Kings and Kern River Basins, where more than 50 percent of the energy used for agriculture-related groundwater pumping occurs. (A detailed discussion of ITRC's model can be found in their report No. 02-001, available on their Web site at www.itrc.org)

source, system, function, and end use will eventually be needed to develop the detailed methodologies on which cost-effective programs can be based.

Water-related energy consumption can then be mapped from the source through various categories of end use to develop a comprehensive understanding of the points and relative magnitudes of energy consumption along the water supply chain, and the types of systems, processes, equipment, and measures that could reduce water and energy consumption at these points. Ideally, a sampling of water utilities that collectively represent most of the primary types of water-energy interdependencies in California would be included in such a pilot. Several water utilities have already indicated interest in participating in such a pilot. These include MWD, IEUA, LADWP, Palo Alto Utilities, Sonoma County Water Agency, and Semitropic Water District.

2. Construct a valuation methodology that accounts for the societal cost (water, energy and externalities) of avoided water consumption for various types of water sources and end uses. Relying upon the data and knowledge gained from detailed studies, quantify the water-energy tradeoffs of various resource decisions through computation of the "Regional Cold-Water Energy Intensity".

    - Research and develop regional cold-water energy intensities (or co-opt existing research), adopt prototypical values, and establish linkage to Forecasting Climate Zones;

    - For existing "cold-water measures" develop base case Unit Energy Consumption (UEC), High-Efficiency (HE) UEC, Base and HE Peak watt and demand savings, volume-sensitive installed measure costs and expected useful life values;

    - Identify and evaluate new cold-water measures targeted to create resource value specifically suited to integrated water/energy resource planning not previously addressed under the discrete/isolated water/energy resource management regime;

    - For new cold-water measures deemed viable, develop planning data identified for existing cold-water measures, and;

    - Incorporate research elements into the Database for Energy Efficiency Resources (DEER) for use by energy-efficiency program planners consistent with program planning protocols enunciated in CPUC Rulemaking 01-08-028, Decision 05-04-051.

The above described methodology is consistent with that employed by the CPUC in its regulation of investor-owned utilities' energy efficiency programs, thus allowing proposed investments in water saving measures to be considered on an equivalent basis.

Objective 3: Implement statewide integrated water and energy resource management.

1. Develop tools and techniques for identifying potential infrastructure upgrades that extend beyond a single utility's service boundaries. The goal of implementing statewide integrated water and energy resource planning and management opens up new opportunities that heretofore have not been considered. Specifically, water and energy utilities presently attempt to optimize their separate resources and systems. Many of these utilities have calibrated their models and tools to simulate their own systems' operations. New analytical models, tools, and methods will be needed to help water and energy utilities look beyond their system boundaries, looking for opportunities to optimize their systems and resources on a joint basis with other water and energy utilities with which they may now be interconnected (or potentially could be interconnected). The underlying premise of joint optimization is that it is at this level of fully integrated planning – i.e., the "nexus" – that the most beneficial incremental benefits will be found.

   Potential opportunities include optimizing the systems and operations of the SWP and the 29 member agencies that comprise its sole customer, the SWC, as well as the CVP, the Colorado River system, and any other points of interconnection along the way.

2. Develop analytical models and tools that:

   - Assist both water and energy utilities in developing joint programs that are cost-effective from a societal point of view;

   - Assist wholesale water utilities in evaluating the net benefits of system reconfigurations or retrofits that exceed their own boundaries[133];

   - Assist both water and energy utilities in assessing the net water supply and associated energy and externalities benefits of proposed measures and retrofits (e.g., assessing the net impact on the water supply balance);l

   - Other analytical models and tools needed to support development and implementation of cost-effective joint water-energy programs.

[133] These may include those that assist the State Water Project operator in making determinations as to how to optimize energy consumption for itself and its customer, the SWC, (and potentially other interconnected systems such as CVP and the Colorado River system) on a combined basis.

Objective 4: Increase water utilities' energy self-sufficiency.

Reduce Energy Consumption:

1. Identify opportunities to reduce conveyance-related peak demand reduction (State Water Project and other large water systems). The State Water Contractors and DWR observed that it might be possible to increase off-peak pumping at Edmonston Pumping Station; however, additional pumping capacity would be needed. In addition, they noted that while there may be opportunities to further increase operational flexibility, additional storage would be needed at points along the aqueduct.[134] In order to assess the statewide opportunity to support such incremental capital expenditures that may be beneficial to the state overall, but are not deemed cost-effective from the perspective of a single entity, the Energy Commission could:

    - Assess and report incremental cost-effective measures that can be implemented to increase pumping capacities and storage to reduce peak energy demands that are cost effective based upon a more comprehensive societal cost-benefit evaluation.

    - Evaluate opportunities to reduce peak demands through coordinated operation of federal and state water projects.

2. Assist water utilities in identifying methods to increase operational flexibility such that energy intensive pumping and water treatment processes could be shifted from on-peak periods, to partial- and off-peak periods.

    - According to ACWA, installation of sensors and other equipment could substantially increase water utilities' flexibility in operating their systems. This flexibility could allow water utilities to maintain minimal pumping loads during peak periods, either by delaying such use into the evening hours or at least by cycling such loads sequentially to minimize peak use.

[134] Reservoirs, depending on location and size, including intake and discharge capacities, provide opportunities for pumping load and generation time-shifting -- hourly/daily shifts for small reservoirs, and sometimes monthly/seasonal shifts for larger reservoirs. For large river reservoirs, like Lake Mead, a downstream re-regulation reservoir such as Lake Mojave could support optimum water deliveries and peak generation. However, Lakes Mead and Mojave increase evaporative losses and incur greater costs and environmental concerns.

Urban hillside tank storage reservoirs that provide system pressure for urban retail water users can be oversized to emphasize off-peak pumping to fill the reservoirs if the pumping capacity in the supply system (say, groundwater wells) is simultaneously increased to produce needed water yield in the less-than-24-hours window. (Note: the pumps can wear out sooner and incur increased operations and maintenance costs if the frequency stop/starts increase to match daily Flex-Your-Power objectives.)

- IEUA has designed its systems to allow water to be “detained” during critical peak periods and held for processing during partial- and off-peak periods.

3. Explore increased use of groundwater storage to allow shifting of summer SWP deliveries to fall. In Southern California, groundwater pumping uses approximately 30 percent of the energy required to import water from Northern California. Groundwater aquifer source production and recharge requirements are fixed and finite. During periods of seasonal peak energy demand, water agencies might rely on groundwater sources and recharge the aquifers using imported water months later in the off-peak season. As noted previously, some Southern California water utilities already choose to pump groundwater during summer and recharge groundwater wells during fall. In this manner groundwater storage capacities could be employed to affect large-scale and long-term seasonal peak demand shifting.

   The potential of increasing groundwater storage capacity to further defer seasonal deliveries should be studied. These studies are complicated, due to unique hydrogeology of groundwater basins and potential linkages among wells. The scope would include:

   - Identification of groundwater aquifers where groundwater pumping and recharge is being performed by water utilities;

   - Identification of groundwater aquifers that are not currently being tapped for groundwater pumping that could be used to affect the aforementioned, and;

   - Assessment of the operational feasibility and associated costs and benefits of potential incremental seasonal demand shifting.

   Analytical tools and techniques will be needed to help determine the efficacy and relative costs vs. benefits of this approach. The study should include consideration of who should develop, fund, own, and operate such assets, which potentially may be constructed primarily for energy benefits (i.e., the value of shifting summer demand to other months).

Increase Power Production:

1. Conduct studies of potential for incremental power production through in-conduit hydropower, pumped storage, and repowering. In-conduit hydropower is a very attractive option since it produces energy as a by-product of water operations. Pumped storage has unique capabilities to produce power during peak periods. The Hetchy Hetchy example illustrated a potential for increasing the state’s hydropower capacity by as much as 10 percent at a fraction of the cost of installing new units and much more quickly.

There are multiple barriers to water utilities' energy self-sufficiency. The statewide potential for increased hydropower and pumped storage capacity should be assessed, and a roadmap developed for attaining this potential that includes potential work-arounds to the policy, regulatory, economic, technical, and other barriers that will need to be overcome.

2. Develop mitigation strategies to reduce lost hydropower capacity during FERC relicensing. As discussed previously, the National Hydropower Association reported that an average of 8 percent of the nation's total hydropower capacity is being lost through relicensing. The Energy Commission could evaluate causes and identify potential mitigation strategies that consider the societal value of associated hydropower capacity.

3. Develop models and tools to evaluate the energy water tradeoff for reservoir storage. Detailed modeling studies of reservoir operations should be performed to evaluate the additional hydropower generated by changing average year reservoir releases. Similarly, conduct studies detailing the decrease in groundwater pump electricity demand associated with a change in average and dry-year reservoir releases.

4. Develop analytical models and tools that assist both water and energy utilities in assessing power production potential by water utilities including, but not limited to:

    - Self-generation utilizing local renewable resources (digester gas[135], agricultural wastes and other biomass, solar,[136] and hydropower).

    - Renewable resource potential for utility scale generation facilities on watershed lands and rights-of-way.[137]

5. Conduct demonstration projects that allow testing of workarounds to barriers and hurdles and verification of net energy and other benefits of water projects that produce energy. In particular, demonstrate means for water utilities to produce energy as a by-product of water delivery and treatment processes (e.g., in-line conduit applications for water and wastewater utilities), and extrapolate statewide potential for these types of opportunities.

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[135] Biogas potential need not be restricted to that produced by sewage digesters. Studies are underway to test the energy potential of blending sewage sludge with other biosolids, such as dairy animal waste and food refuse. In addition to increasing power production, this process provides an attractive means for disposing of other types of waste products. In addition, some parties are investigating development of a sludge-derived solid fuel that could be burned in power plants.

[136] Solar power is well suited to meeting small pumping loads in water distribution systems.

[137] Water utilities' extensive watershed land holdings could provide good opportunities for utility-scale wind and concentrating solar power development.

6. Conduct a comprehensive resource assessment of the renewable resource potential of watershed lands and rights-of-way and determine the barriers and hurdles that would need to be overcome.

Objective 5: Increase water efficiency and demand-side management.

1. Develop a pilot program that evaluates societal benefits of water conservation and efficiency programs presently deemed non-cost-effective under traditional water utility planning criteria. Potential items include: new balanced irrigation systems, weather based-irrigation systems, drought tolerant plant/low runoff landscape retrofits, synthetic turf retrofits, free water brooms for every school, connectionless water steamers, digital x-ray machines or x-ray water recirculation systems for doctors and hospitals, free cooling tower conductivity controllers for all public schools and buildings (may be commercial uses too), small scale water recycling projects for communities and golf courses, incentives for new home owners to buy water/energy efficient new homes, large-scale irrigation controllers and landscape retrofits for parks and greenbelts, water softeners[138], etc.

2. Expand the 14 BMPs to include other water conservation measures that meet the more comprehensive "societal" resource test. Building on the important work by CUWCC and its members, Pacific Institute, and other key stakeholders, identify and value incremental measures that can help meet the goals for a comprehensive statewide water-energy program. These measures should then be ranked alongside other feasible water and energy efficiency options on the basis of highest benefit:cost ratio, and then incorporated into joint water-energy programs.

3. Continually improve agricultural water use efficiency.
   - Continue to implement the PIER Agricultural Irrigation Technology Roadmap calling for research and development efforts improve irrigation efficiency. Possible studies include:

     - Reduce the total pressure required to operate drip irrigation technologies; this includes the filter system as well as the pipe and micro-sprayer technologies.

     - Advance the use of longer lasting materials for pump components.

     - Work with the SWP, the CVP and the irrigation districts to increase the flexibility of water deliveries to farms.

[138] One California water agency performed an analysis of retrofits of water softeners. The program did not meet the cost-effectiveness threshold on water alone, but the societal benefits are potentially large.

- Learn more about the increasing trend to adopt drip/micro systems, the implications to energy consumption, and the energy management benefits the systems provide.

- Work with irrigation districts to understand the ramifications increased reliance on groundwater.

- Work with the CPUC to ensure appropriate implementation of Critical Peak Pricing and other TOU rates.

- Work with the CPUC, the utilities, the irrigation districts, and the farmers to ensure widespread use of available energy efficiency programs.

4. Reduce outdoor water consumption. In the context of greatest near-term benefit, there is no dispute among stakeholders: The single largest opportunity for saving a lot of water quickly is through reductions of outdoor water use, both in agricultural and landscape irrigation.

    - Pacific Institute stated that more than 75 percent of the state's total water consumption is used by agriculture.

    - IEUA stated that during summer, outdoor water use for landscape irrigation accounts for 50 to 70 percent of all water consumed by the residential sector. Regions along the coast tend to use less; hotter interior uses more. Seasonal factor translates into even bigger impacts. Overall, reducing residential usage from 200 gal per capita daily down to 80 gal per capita daily (SF/LA numbers).

    - MWD stated that the biggest opportunity for outdoor water savings is in landscape replacement with native plants and synthetic turf.

5. Reduce industrial water use. Pacific Institute estimates that as much as 658,000 AF/year could be saved by the commercial and industrial sectors. Opportunities include joint investment in existing water savings programs, as well as potential joint investment in new technologies. MWD, for example, suggests joint investigation of innovative conservation program investments in industrial process water improvements, such as optimal approaches to industrial recirculation. In addition, this program could include investigation of new water efficiency technologies for various types of industrial processes.

6. Explore a "Golden Carrot" equivalent for water conservation programs. Develop joint investment opportunities in use funds to conduct innovative conservation program investigations into new technology and to kick start methods of obtaining water customer responses to these opportunities. One or more cash and other prizes could be awarded through a competitive innovation program that includes, for example, a call for water and energy-efficient home water heating systems and improvements.

Glossary

acre-foot (AF) - a quantity or volume of water covering one acre to a depth of one foot; equal to 43,560 cubic feet or 325,851 gallons.

active storage capacity - the total usable reservoir capacity available for seasonal or cyclic water storage. It is gross reservoir capacity minus inactive storage capacity.

adjudication - the act of judging or deciding by law. In the context of an adjudicated groundwater basin, landowners or other parties have turned to the courts to settle disputes over how much groundwater can be extracted by each party to the decision.

afterbay - a reservoir that regulates fluctuating discharges from a hydroelectric power plant or a pumping plant.

alluvium - a stratified bed of sand, gravel, silt, and clay deposited by flowing water.

aquifer - a geologic formation that stores and transmits water and yields significant quantities of water to wells and springs.

artificial recharge - the addition of water to a groundwater reservoir by human activity, such as putting surface water into dug or constructed spreading basins or injecting water through wells.

average annual runoff - the average value of annual runoff amounts for a specified area calculated for a selected period of record that represents average hydrologic conditions.

brackish water - water containing dissolved minerals in amounts that exceed normally acceptable standards for municipal, domestic, and irrigation uses. Considerably less saline than sea water.

conjunctive use - the coordinated and planned management of both surface and groundwater resources in order to maximize the efficient use of the resource; that is, the planned and managed operation of a groundwater basin and a surface water storage system combined through a coordinated conveyance infrastructure. Water is stored in the groundwater basin for later and planned use by intentionally recharging the basin during years of above-average surface water supply.

contaminant - any substance or property preventing the use or reducing the usability of the water for ordinary purposes such as drinking, preparing food, bathing washing, recreation, and cooling. Any solute or cause of change in physical properties that renders water unfit for a given use. (Generally considered synonymous with pollutant.)

conveyance - provides for the movement of water and includes the use of natural and constructed facilities including open channels, pipelines, diversions, fish screens distribution systems, and pumplifts.

cost-effective - means that the benefit-to-cost ratio of a proposed program or measure exceeds 1.0. As applied to this test, both costs and benefits are measured either over the life of the program or in terms of societal cost. Water and energy utilities currently include only costs and benefits that affect their respective ratepayers in their cost-effectiveness computations. The conclusion of this staff paper is that a cost-effectiveness test should expand to include all economic, environmental, and societal costs and benefits over the entire water use cycle - even those extending beyond the boundaries of a utility's service territory, resources, and assets - in order to identify opportunities to benefit the state as a whole.[139]

desalination - water treatment process for the removal of salt from water for beneficial use. Source water can be brackish (low salinity) or seawater.

drainage basin - the area of land from which water drains into a river; for example, the Sacramento River Basin, in which all land area drains into the Sacramento River. Also called, "catchment area," "watershed," or "river basin."

drip irrigation - a method of microirrigation wherein water is applied to the soil surface as drops or small streams through emitters. Discharge rates are generally less than 8 L/h (2 gal/h) for a single outlet emitters and 12 L/h (3 gal/h) per meter for line-source emitters.

drought - the magnitude and probability of economic, social or environmental consequences that would occur as a result of a sustained drought under a given study plan. Measures the "drought tolerance" of study plans.

energy consumption - the energy consumption required to facilitate water management-related actions such as desalting, pump-storage, groundwater extraction, conveyance, or treatment. This criterion pertains to the economic feasibility of a proposed action in terms of O&M costs.

energy costs - refers to the cost of energy use related to producing, conveying and applying water. It also refers to the cost of energy use for processes and inputs not directly related to water, but which can affect the demand for water (e.g., the cost of nitrogen fertilizer, tractor manufacturing, etc.).

energy production - both instantaneous capacity (megawatt) and energy produced (kilowatt hours).

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[139] Eventually, the issue as to who pays for such incremental statewide benefits will also need to be addressed.

energy self-sufficiency – Refers to an entity that self-supplies its own energy requirements. This would typically be done through a combination of energy efficiency and self-provision of power, whether purchased or produced. Current regulatory barriers prevent water and wastewater utilities from becoming energy self-sufficient.[140]

effluent - wastewater or other liquid, partially or completely treated or in its natural state, flowing from a treatment plant.

end use – the use of energy or water for specific activities such as heating, cooling, toilets, or irrigation.

end users – the consumers of energy or water.

estuary - the lower course of a river entering the sea influenced by tidal action where the tide meets the river current.

evapotranspiration (ET) - the quantity of water transpired (given off), retained in plant tissues, and evaporated from plant tissues and surrounding soil surfaces. Quantitatively, it is usually expressed in terms of depth of water per unit area during a specified period of time.

forebay - a reservoir or pond situated at the intake of a pumping plant or power plant to stabilize water levels; also a storage basin for regulating water for percolation into ground water basins.

gigawatt (GW) - one thousand megawatts (1,000 MW) or one million kilowatts (1,000,000 kW) or one billion watts (1,000,000,000 watts) of electricity. One gigawatt is enough to supply the electric demand of about one million average California homes.

gigawatt-hour (GWh) - one million kilowatt-hours of electric power. California's electric utilities generated a total of about 250,000 gigawatt-hours in 2001.

gross reservoir capacity - the total storage capacity available in a reservoir for all purposes, from the streambed to the normal maximum operating level. Includes

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[140] Barriers to energy self-sufficiency include:
(a) Long lead-time, complicated and costly interconnections;
(b) Prohibitive stand-by charges for grid-connected self-generation facilities:
(c) Net metering caps that discourage self-production of power at any site in an amount greater than 1MW (or the then current cap);
(d) Inability to “wheel” self-produced and/or purchased power to themselves anywhere on their own system (causing excess power to be either “lost” or sold at uneconomic wholesale prices that do not recover costs;
(e) Lack of standardized contracts, rates and terms for purchasing self-produced power that exceeds water and wastewater utilities’ needs at prices that at least recover costs; and
(f) Prohibitive exit fees assessed to entities departing from bundled electric utility service.

dead (or inactive) storage, but excludes surcharge (water temporarily stored above the elevation of the top of the spillway).

groundwater - water that occurs beneath the land surface and completely fills all pore spaces of the alluvium, soil or rock formation in which it is situated. It excludes soil moisture, which refers to water held by capillary action in the upper unsaturated zones of soil or rock.

groundwater basin - a groundwater reservoir, defined by an overlying land surface and the underlying aquifers that contain water stored in the reservoir.

groundwater overdraft - the condition of a groundwater basin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years during which water supply conditions approximate average.

groundwater recharge - increases in groundwater storage by natural conditions or by human activity.

groundwater table - the upper surface of the zone of saturation, except where the surface is formed by an impermeable body.

hydraulic barrier - a barrier developed in the estuary by release of fresh water from upstream reservoirs to prevent intrusion of sea water into the body of fresh water.

hydrologic balance - an accounting of all water inflow to, water outflow from, and changes in water storage within a hydrologic unit over a specified period of time.

hydrologic basin - the complete drainage area upstream from a given point on a stream.

hydrologic region - a study area, consisting of one or more planning subareas.

infiltration - the flow of water downward from the land surface into and through the upper soil layers.

irrigation efficiency (IE) - the efficiency of water application and use, calculated by dividing a portion of applied water that is beneficially used by the total applied water, expressed as a percentage The two main beneficial uses are crop water use (evapotranspiration, etc.) and leaching to maintain a salt balance.

kilovolt (kV) - one-thousand volts (1,000). Distribution lines in residential areas usually are 12 kv (12,000 volts).

kilowatt (kW) - one thousand (1,000) watts. A unit of measure of the amount of electricity needed to operate given equipment. On a hot summer afternoon a typical

home, with central air conditioning and other equipment in use, might have a demand of 4 kW each hour.

kilowatt-hour (kWh) - the most commonly-used unit of measure telling the amount of electricity consumed over time. It means one kilowatt of electricity supplied for one hour. In 1989, a typical California household consumes 534 kWh in an average month.

land subsidence - the lowering of the natural land surface due to groundwater (or oil and gas) extraction.

maximum contaminant level (MCL) - the highest drinking water contaminant concentration allowed under federal and State Safe Drinking Water Act regulations.

megawatt (MW) - one thousand kilowatts (1,000 kW) or one million (1,000,000) watts. One megawatt is enough energy to power 1,000 average California homes.

methane (CH_4) - the simplest of hydrocarbons and the principal constituent of natural gas. Pure methane has a heating value of 1,1012 Btu per standard cubic foot.

methanol (also known as Methyl Alcohol, Wood Alcohol, CH_3OH) - a liquid formed by catalytically combining carbon monoxide (CO) with hydrogen (H_2) in a 1:2 ratio, under high temperature and pressure. Commercially it is typically made by steam reforming natural gas. Also formed in the destructive distillation of wood.

microirrigation - the frequent application of small quantities of water as drops, tiny streams, or miniature spray through emitters or applicators placed along a water delivery line. Microirrigation encompasses a number of methods or concepts such as bubbler, drip, trickle, mist, or spray.

minimum pool - the reservoir or lake level at which water can no longer flow into any conveyance system connected to it.

natural recharge - natural replenishment of an aquifer generally from snowmelt and runoff; through seepage from the surface.

percolation - process in which water moves through a porous material, usually surface water migrating through soil toward a groundwater aquifer.

photovoltaic cell - a semiconductor that converts light directly into electricity.

public water system - a system for the provision of water for human consumption through pipes or other constructed conveyances that has 15 or more service connections or regularly serves at least 25 individuals daily at least 60 days out of the year.

recharge - water added to an aquifer or the process of adding water to an aquifer. Groundwater recharge occurs either naturally as the net gain from precipitation or artificially as the result of human influence.

recycled water - the process of treating municipal, industrial, and agricultural wastewater to produce water that can be productively reused.

riparian right - a right to use surface water, such right derived from the fact that the land in question abuts the banks of streams.

runoff - the volume of surface flow from an area.

salinity - generally, the concentration of mineral salts dissolved in water. Salinity may be expressed in terms of a concentration or as electrical conductivity. When describing salinity influenced by seawater, salinity often refers to the concentration of chlorides in the water.

seawater intrusion barrier - a system designed to retard, cease or repel the advancement of seawater intrusion into potable groundwater supplies along coastal portions of California. The system may be a series of specifically placed injection wells where water is injected to form a hydraulic barrier.

single utility resource cost test - refers to resource optimization from the perspective of a single utility - for example, a water utility already seeking optimization of its own water resources. Energy costs embedded in delivered wholesale water are included when considering cost-effectiveness. However, the single utility resource cost test does not evaluate the impact of these water resource decisions on either water or energy utilities, or on statewide water and energy resources and infrastructure. Similarly, neither water nor energy utilities consider the energy intensity embedded in a unit of avoided water over the entire water use cycle.

societal cost or societal value - refers to the total resource cost, including water and energy and externalities, embedded in a unit of water. For purposes of this staff paper, this term is consistent with that used by the California Public Utilities Commission when determining the cost-effectiveness of energy efficiency programs and measures, and by water utilities when determining the cost-effectiveness of their water conservation incentive programs.[141]

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[141] The CPUC's Energy Efficiency Policy Manual, Chapter 4 Cost-Effectiveness Methodology, relies upon a "Total Resource Cost (TRC) test - Societal Version" as "articulated [in] the California Standard Practices Manual: Economic Analysis of Demand-Side Management Programs." The California Standard Practices Manual states that "The Total Resource Cost Test measures the net costs of a demand-side management program as a resource option based on the total cost of the program, including both the participant's and the utility's costs." "A variant on the TRC test is the Societal Test. The Societal Test differs from the TRC test in that it includes the effects of externalities, excludes tax credit benefits, and uses a different (societal) discount rate." Water conservation incentives are typically valued in accordance with the February 1994 EPA manual, "A Guide to Customer Incentives

surface supply - water supply obtained from streams, lakes, and reservoirs.

surplus water - water that is not being used directly or indirectly to benefit the environmental, agricultural or urban use sectors.

tailwater – the excess water that was applied for agricultural irrigation water. This water is either returned to the environment or reused for irrigation.

transpiration - an essential physiological process in which plant tissues give off water vapor to the atmosphere.

Urban Water Management Planning Act – Sections 10610 through 10657 of the California Water Code. The Act requires urban water suppliers to prepare urban water management plans which describe and evaluate sources of water supplies, efficient uses of water, demand management measures, implementation strategies and schedules, and other relevant information and programs within their water service areas. Urban water suppliers (CWC Section 10617) are either publicly or privately owned and provide water for municipal purposes, either directly or indirectly, to more than 3,000 customers or supply more than 3,000 acre-feet of water annually.

volt - a unit of electromotive force. It is the amount of force required to drive a steady current of one ampere through a resistance of one ohm. Electrical systems of most homes and office have 120 volts.

water balance - an analysis of the total developed/dedicated supplies, uses, and operational characteristics for a region.

water quality - description of the chemical, physical, and biological characteristics of water, usually in regard to its suitability for a particular purpose or use.

watershed - the land area from which water drains into a stream, river, or reservoir.

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for Water Conservation" which incorporates by reference the societal valuation approach adopted in the California Standard Practice Manual.

Document 10

2013

Southern California Edison

Corporate Responsibility Report

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About This Report

This year's report reflects SCE's operations in 2013. Inside, we describe the company's progress in serving our customers, supporting our communities, partnering with our employees and protecting the environment.

Corporate responsibility remains the foundation from which we operate our business each and every day. We know that our success depends on the quality, productivity and engagement of our employees. We work together to demonstrate our shared values: committing to put safety first; to conduct ourselves with integrity; to encourage collaboration, to cultivate a diverse, inclusive culture in which every employee is valued and respected; and to do the right thing for customers, fellow employees, investors, suppliers and our communities. We strive to be transparent and straightforward when we discuss our business performance. Your feedback continues to guide our reporting. To share your thoughts and suggestions, please contact us at **CRreport@sce.com.**

Our Values

- Integrity
- Excellence
- Respect
- Continuous Improvement
- Teamwork

Our Operating Priorities

- We operate safely
- We meet customer needs
- We value diversity
- We build productive partnerships
- We protect the environment
- We learn from experience and improve
- We grow the value of our business

Company Overview

A subsidiary of **Edison International** (NYSE:EIX), Southern California Edison is an investor-owned utility and one of the nation's largest electric utilities, serving a population of nearly 14 million in a 50,000-square-mile service area within central, coastal and southern California.

SCE At A Glance – 2013

5 Million (Approx.)	**Customer Accounts**
$900 Million	**Net Income**
$12.5 Billion	**Total Operating Revenue**
$46 Billion	**Total Assets**
87,397 Million Kilowatt-Hours	**Total Electricity Sales**
13,654	**Full-TIme Employees**
13	**Directors On SCE Board**
10	**Independent SCE Board Members**
5	**Ethnic Minority SCE Board Members**
2	**Female SCE Board Members**

Ron Litzinger
President, SCE

President's Message

The accelerating pace of change in the electric power industry is fundamentally altering the way electricity is generated, delivered and consumed. There are several long-term trends that we expect will continue to significantly influence the industry, such as public policy prioritizing environmental sustainability; technology and financing innovations facilitating energy conservation and self-generation; regulation supporting new forms of competition; and flattening demand for electricity.

California is at the vanguard of electric industry change. We have responded with concrete steps to prepare our company to meet the opportunities and challenges ahead as well as customers' expectations for more choices and greater control of their energy usage.

Southern California Edison's core mission remains what it has been since the company was founded: safely providing reliable and affordable electric service to our customers. Our employees continue to rely on the company's core values — Integrity, Excellence, Respect, Continuous Improvement and Teamwork — to deliver on that mission, even as we develop new business opportunities to adapt and thrive as the industry reshapes.

Decommissioning San Onofre

Last June, we made the decision to close the San Onofre Nuclear Generating Station. This was not a decision made lightly. San Onofre produced clean and reliable baseload power for our customers for more than 40 years. Over those years, it employed thousands of dedicated men and women. But the process to gain regulatory approval to restart Unit 2 became a long and drawn-out affair, and we concluded that the continuing uncertainty was not in the best interest of our customers, our employees, our shareholders, and the need to plan for California's long-term energy needs. San Onofre's 2,200

In October 2014, Ronald L. Litzinger became president of Edison International subsidiary Edison Energy, and Pedro J. Pizarro succeeded him as president of SCE.

megawatts of peak output was enough to reliably power 1.4 million homes and supplied about 19 percent of our region's electricity. Going forward, our focus is on two objectives: Planning for replacement resources required for grid reliability, and decommissioning San Onofre safely, efficiently, and as quickly as practical.

Building the Next Generation Electric Grid

Delivering electricity is SCE's core business. More than five million customers depend on us 24/7/365. These customers have told us that they want cleaner air and water, a healthy environment, and an electric power system that supports those goals.

A central tenet of SCE's business strategy is that we should lead the transformation of the distribution system from one that is designed for one-way flows of electricity to an advanced and flexible system capable of two-way electrical flows. Such a system is needed to better facilitate distributed energy resources, such as rooftop solar, electric vehicles and energy storage, while maintaining safety, grid reliability and power quality.

Building this next-generation grid requires significant technical know-how and capital investment, something we are particularly well positioned to advance.

In September 2013, SCE launched its Preferred Resources Pilot (PRP) in south Orange County, Calif., to inform the clean energy grid of the future by increasing the overall use of preferred resources – energy efficiency, demand response, renewable resources and energy storage – and determining their local grid-level impact. The lessons learned from the PRP will be applied to other grid areas to assist SCE's efforts to maintain the highest level of reliability and customer affordability while reducing greenhouse gas emissions.

Focus on Continuous Improvement

The foundation for growth and positioning SCE for the future is operational and service excellence. Our customers demand reliable service at a reasonable cost. This requires us to constantly become more efficient, to change our organizational habits and to increase productivity. We also must integrate new technologies that allow us to better manage the grid. Doing these well permits us to better serve our customers and meet new forms of competition.

We have much to accomplish in 2014 and beyond to further strengthen our core business and prepare for the changes in our industry. I have confidence in the ability of our employees to execute our strategy and capitalize on the opportunities ahead.

This report illustrates SCE's multi-layered approach to corporate responsibility. As you read this year's report, we encourage you to share your feedback at CRreport@sce.com. We welcome the engagement and dialogue with our customers, communities and stakeholders, and I thank you for your interest in our company.

Sincerely,

Ron Litzinger
President, Southern California Edison

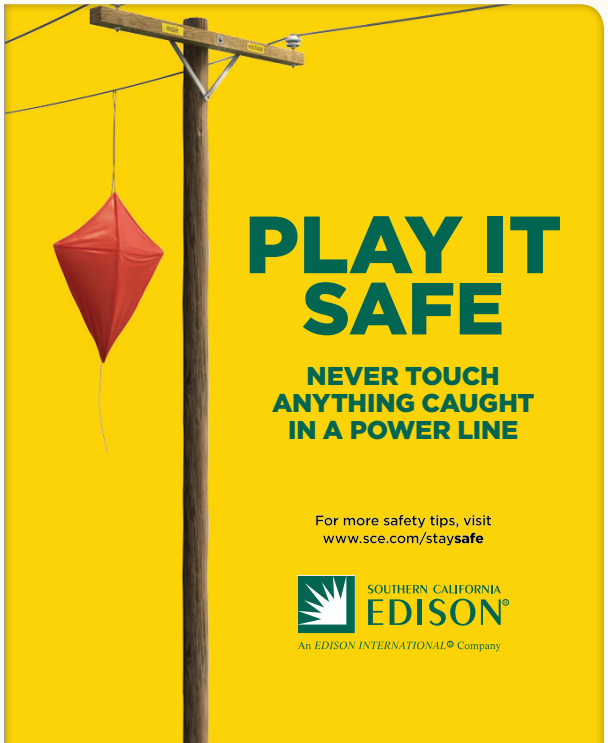
Safety First

"We Operate Safely" is Southern California Edison's top priority. We put safety first in our workplaces and communities, and our goal is to achieve a zero-injury culture.

Public Safety

SCE is committed to providing its customers with the information they need to keep themselves, their loved ones and their neighbors safe around electricity. The company continued its safety advertising campaign throughout 2013 in multiple languages (English, Spanish, Chinese, Khmer, Korean, Tagalog and Vietnamese) and through multiple media channels (TV, radio, print, online, out-of-home/outdoor) to help build and reinforce public awareness of safety around power lines. The campaign reached a broad audience, resulting in more than 1.8 billion advertising appearances.

Outdoor ad from SCE Public Safety campaign.



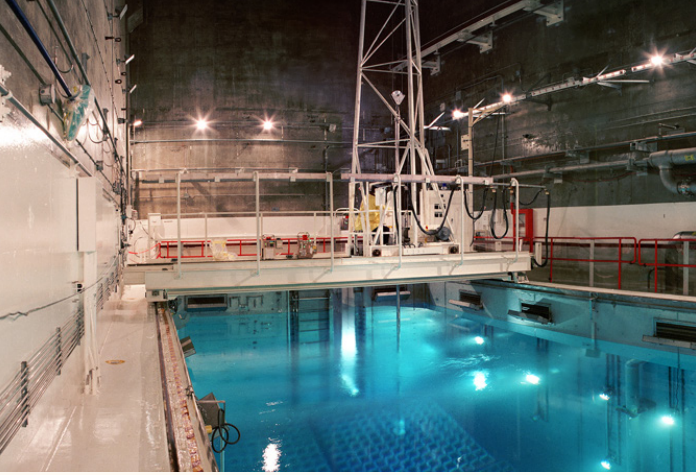
SCE also used community forums (see "Strong Communities") to spread the message about safety around downed power lines with leaders from community-based organizations.

The company is working with local communities to improve first responders' awareness of electrical safety. In 2013, SCE conducted 102 Community Emergency Response Team sessions, educating more than 3,500 attendees about topics such as safely responding to downed power lines, SCE's process to restore electric service, and how to get involved in community emergency response efforts.

As part of the PrepareSoCal emergency preparedness campaign, organized by the American Red Cross in partnership with Edison International, more than 600 emergency and continuity planners from numerous businesses, government agencies, nonprofits and faith-based organizations participated in the 29th annual Disaster Preparedness Academy at the Anaheim Convention Center in October 2013. Attendees received training on emergency preparedness, response and recovery.

SCE linemen team up with firefighters in public safety TV ads.

SCE offers "Worker Beware" safety training materials at no cost to construction, agricultural, tree trimming and other workers whose jobs may bring them in proximity to SCE power lines. These materials — which include tip cards, posters, a DVD and a facilitator's guide — can help save lives. SCE mailed these training materials to more than 112,000 business owners in 2013.



Spent fuel pool at SONGS.

Nuclear Plant Safety

Decommissioning the San Onofre Nuclear Generating Station safely, efficiently and as quickly as practical has been a priority since the company made the difficult decision to close the plant in June 2013. Employees began preparations to decommission Units 2 and 3 (Unit 1 operated from 1968 to 1992). SCE subsequently certified to the Nuclear Regulatory Commission that all fuel had been removed from both reactors and began a detailed planning process to safely dismantle the plant. The used nuclear fuel will continue to be stored safely in a concrete, steel-lined spent fuel pool until it is transferred to dry cask storage containers. SCE plans to complete this transfer to dry storage in 2019.

San Onofre already has 51 dry cask storage containers containing used fuel from Units 1, 2, and 3. The used fuel will be stored safely on site until the federal government fulfills its contractual obligation to open a permanent spent fuel facility. Dry cask storage systems are designed to withstand various natural phenomena such as floods, projectiles from a tornado, seismic events, temperature extremes and lightning strikes.

The NRC has strict rules governing cleanup of radioactively contaminated plant systems and structures. Before major dismantlement of San Onofre begins (tentatively scheduled for early 2016), SCE will submit to the NRC a detailed decommissioning plan called a Post-Shutdown Decommissioning Activities Report. SCE has announced that safety, stewardship and engagement will serve as the company's guiding principles to make the San Onofre decommissioning a model for the industry. More information about the plans to decommission San Onofre can be found at **www.songscommunity.com.**

Employee Safety

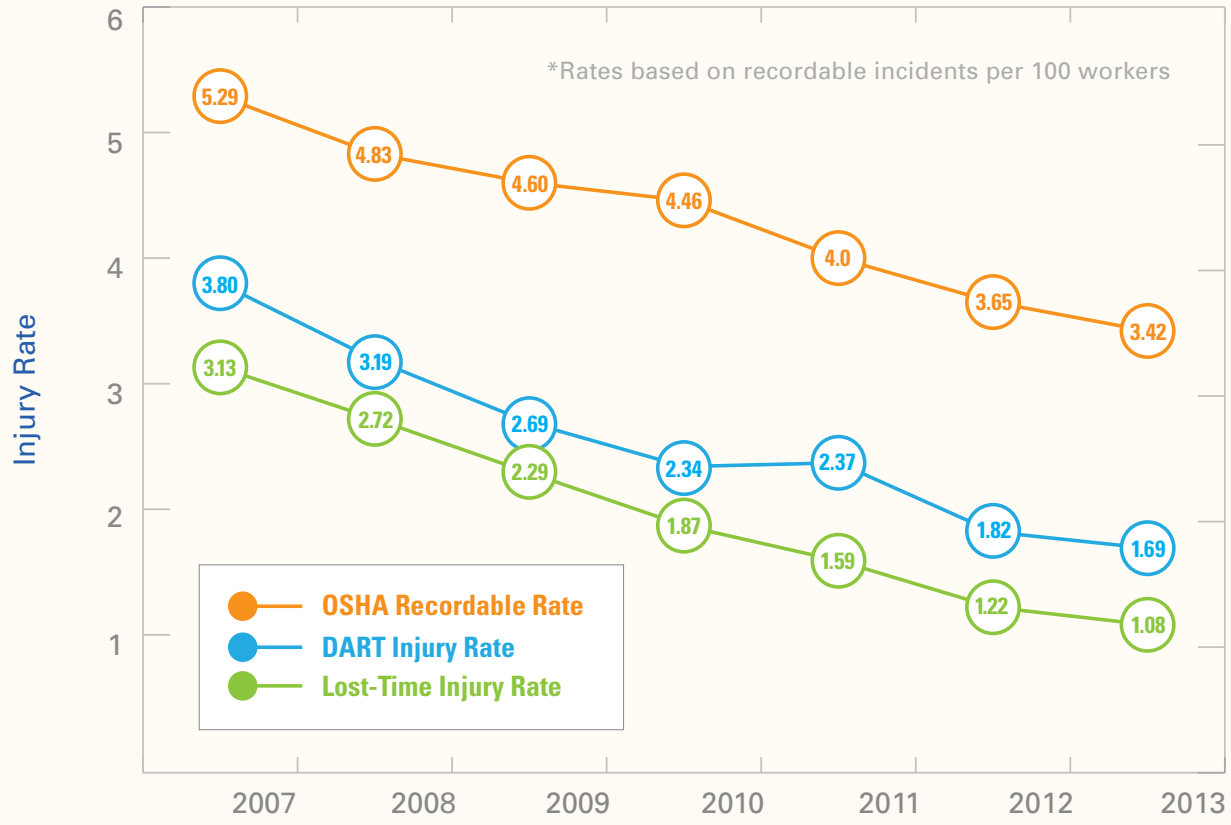
SCE's safety performance continued to improve in 2013. However, we didn't meet our most important goal: zero fatalities. Sadly, two of our co-workers lost their lives last year – one contractor and one employee. These and other events are reminders that many of our employees work in hazardous environments. We will continue to investigate and learn from all safety incidents, and we will continue to implement initiatives to improve our safety culture. We can never be satisfied with our performance until everyone goes home safely at the end of the day.

At SCE, we are committed to strengthening our safety culture to achieve an injury-free workplace. We aim to create and sustain a working environment where what matters most is:

- Having every employee leave the workplace unhurt
- Using work behaviors and practices that uncompromisingly protect the safety of everyone
- Caring for the safety of everyone
- Stopping work anytime unsafe conditions or behaviors are observed until the job can be completed safely

OSHA and DART Rates

In 2013, SCE continued to make progress in the two primary ways we measure our safety performance: the rate of workplace injuries reportable to the Occupational Safety and Health Administration (OSHA), and "Days Away, Restricted and



Transferred" (DART) rate, which measures injuries serious enough to cause an employee to lose time away from work, or that require the employee to be on restricted duty. Our performance in both categories improved in 2013 versus 2012. Our OSHA rate decreased by 6 percent, and our DART rate decreased 7 percent from 2012 levels.

Company-Wide Safety Initiatives

In 2013, SCE introduced two new company-wide safety programs. Safety Observation encourages employees to have safety-focused conversations with colleagues, pointing out hazards as well as safe and unsafe behaviors. In the Close Call program, employees are encouraged to report incidents that could have resulted in an injury but didn't.

We have learned that companies which are leaders in safety performance have robust Safety Observation and Close Call programs for their employees. The programs identify leading indicators to increase safety, mitigate potential injury, and share information about potentially unsafe conditions/close calls which pose the risk of more serious consequences. By identifying hazards and correcting unsafe behaviors, our goal is to avoid future injuries.

Craft Driven Safety Program

SCE's Transmission & Distribution organization launched the Craft Driven Safety Program (CDSP) in 2012 in partnership with the International Brotherhood of Electrical Workers Local 47. The program was conceptualized by the electrical "craft" employees who work directly with both energized and de-energized electrical equipment to improve safety performance, safety culture and morale.

In 2013, T&D's existing Safety Observation and Close Call efforts (similar to the company-wide versions), and its existing Lessons Learned meetings were enhanced and expanded. At the Lessons Learned meetings, craft employees lead discussions about any recent incidents, share common findings, share the importance of following fundamentals, and fully commit to safety. T&D also enhanced and expanded its physical therapeutic exercise program, customizing it by work function.

Electrical Reliability

Safely delivering reliable electricity is a top priority for SCE. We focus on continuous improvement to reduce both the number and duration of outages.

Reliability Performance

System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI) are the metrics that help SCE monitor how well we are "keeping the lights on" for our customers. SAIDI tells us how long an average customer is without power, and SAIFI indicates how often they lose power during the year.

	2011	2012	2013
Average number of outages (occurrences)	0.91	0.86	0.88
Average time without power (minutes)	108.2	100.7	94.5

* Does not include Major Event Days (MEDs), as defined by IEEE Standard 1366

In 2013, the average SCE customer experienced less than one sustained outage each year, and was without power for less than 1.6 hours, a fraction of the nearly 8,800 hours in a year. In the most recent Institute of Electrical and Electronics Engineers survey, which compares more than 100 utilities nationwide, SCE's 2013 SAIFI performance was in the top quartile, and its SAIDI performance missed the top quartile by less than 2 minutes. SCE is committed to striving for even greater service reliability for all of our customers.

Nearly

1.5 Million

utility poles in SCE's service territory

Distribution System Investments

To develop a long-term trend of first-rate reliability, SCE has implemented a program to test distribution cable and substation equipment, such as transformers and circuit breakers, and to identify what equipment should be replaced prior to the end of its service life, in order to prevent outages and to enable quicker service restoration when outages do occur.

The company is making significant, cost-effective investments in our distribution system to improve reliability while maintaining affordable rates. Among the 2013 accomplishments in its distribution infrastructure replacement programs, SCE replaced 355 conductor miles of aging primary distribution cable, replaced 322 aging distribution capacitor banks, and rehabilitated 298 circuits in the greatest need of repair.

Linemen attend to one of SCE's nearly 1.5 million utility poles.

Pole Loading Program

SCE's electrical grid utilizes nearly 1.5 million utility poles, with 70 percent of the poles jointly owned with other utilities. These poles undergo routine inspections, maintenance, and upgrades. This work will be accelerated as the company launches its system-wide Pole Loading Program (PLP) to assess every utility pole throughout our 50,000 square mile territory and bring the poles up to specified standards, including safety standards that in some cases exceed minimum regulatory requirements.

115,000 +

miles of transmission lines in SCE's service territory

SCE will focus first on the areas where risk of high winds and fire is greater. Any poles requiring maintenance will be repaired or replaced. The program is part of our ongoing investment in ensuring reliable electric service.

In 2013, 16,337 distribution poles and 1,159 transmission poles were replaced as part of routine ongoing maintenance. In addition, pole loading calculations were performed on 5,000 poles as part of a 2012 General Rate Case (GRC) study, a contractor was selected to execute the PLP, and field tests were completed in anticipation of program assessments launching in January 2014.

Summer Readiness

With the retirement of the San Onofre nuclear plant, SCE has worked to ensure that there is enough power for the hottest days of summer across our territory. That required accelerating transmission upgrades and sourcing new generation; for example, reconfiguring the existing 220-kV Barre-Ellis transmission line from two circuits to four, increasing the amount of electricity that the transmission lines can transport.

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On the cybersecurity front lines: (l-to-r) SCE's Aleida Gonzalez and Chris Clarke.

Cybersecurity

Cybersecurity is critical for ensuring safety, reliability and resiliency of the electric system; it has become increasingly important because the grid of the future is expected to be a plug-and-play infrastructure that provides for two-way power flows, and accommodates new technologies that may not be owned or operated by SCE.

SCE is going beyond compliance with federal cybersecurity requirements by incorporating military grade technology into our grid and actively engaging with government agencies to share information on threats and protection measures.

In November 2013, SCE participated in the North American Electric Reliability Corporation's (NERC's) second GridEx grid security exercise with 125 other utilities, government agencies, and private companies from across the U.S. and Canada. It was designed to measure the readiness of utilities and government agencies to respond to a cyber-attack. The two-day exercise put us through a series of simulated exercises that mimic what could happen during an actual cyber or physical attack on the electric grid. Exercises like this help to assess current command and communications plans, and identify areas for improvement.

Security for Facilities

In the past several years, SCE corporate security has focused on deploying security measures to provide protections commensurate to the industry threats, such as theft of copper, tools and damage/loss of company equipment. The April 2013 attack on a transmission substation located south of San Jose provided another type of potential threat our company faces. SCE drives a strategic approach to physical security by identifying the critical facilities and necessary protections to support the business objective of delivering safe and reliable power to SCE customers.

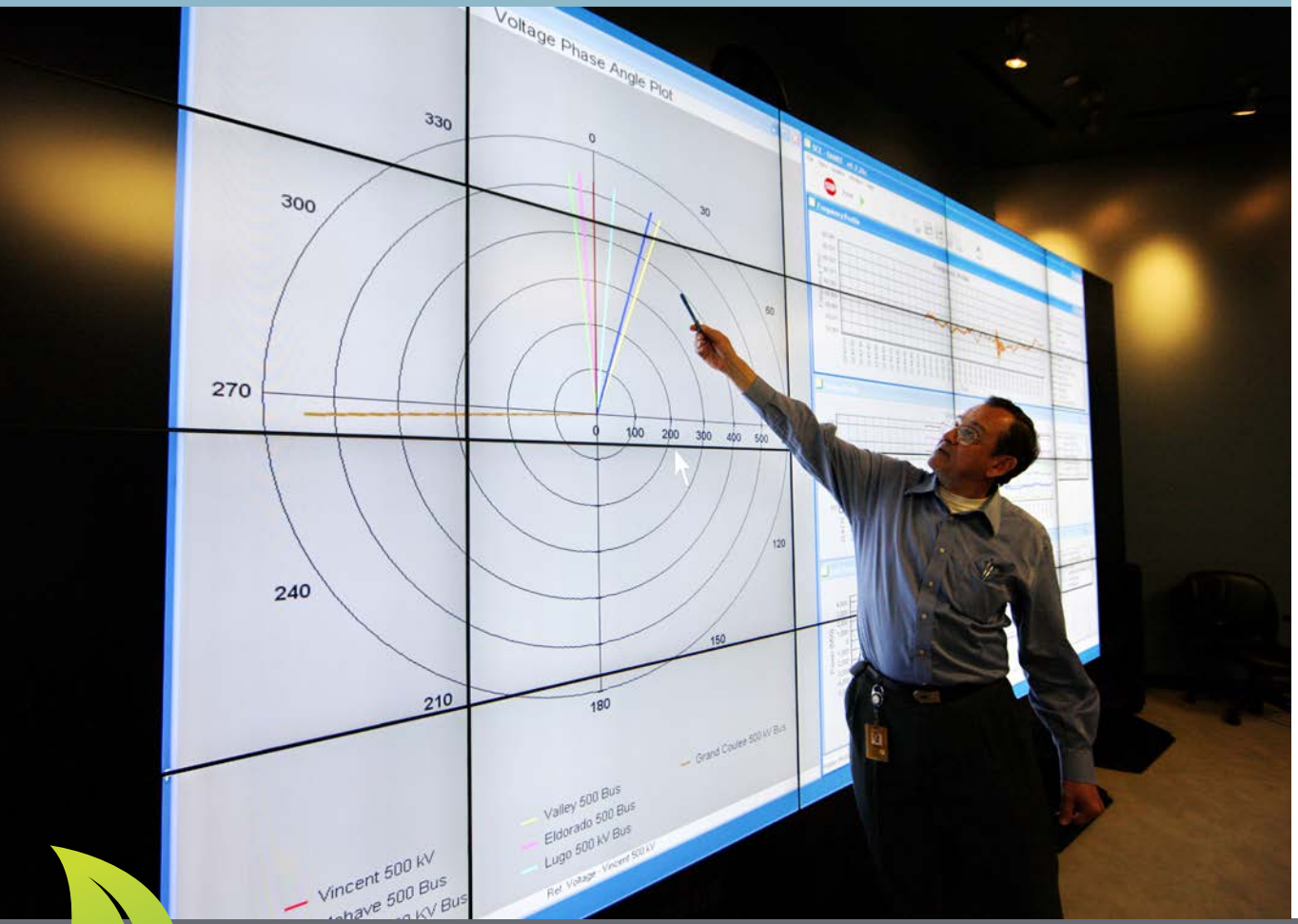
Activities from this strategic approach include:

- Documenting procedures and training personnel for the prompt reporting and response to events that occur on the electrical system, including acts of sabotage and terrorism.
- Deploying armed and unarmed security officers at appropriate locations.
- Working with appropriate law enforcement to ensure they understand the criticality of the facilities in their respective areas of jurisdiction.

Building a 21st Century Power Network

SCE is working to create a 21st century power network that can handle our electricity needs – one that includes rooftop solar, energy storage and other state-of-the-art energy technologies. Upgrades to the power network will allow SCE to incorporate more distributed energy resources, so that we can use clean energy without compromising safety and reliability.

The Irvine Smart Grid Demonstration is based at SCE's Advanced Technology Lab.



In 2013,

26,372

new solar customer interconnections, ranking second among utilities nationwide

The Irvine Smart Grid Demonstration (ISGD), co-funded by a U.S. Department of Energy grant, is evaluating new technologies to assess their role in the next generation of the electric grid.

Among the technologies being tested at ISGD are:

- A self-healing distribution circuit that automatically detects and isolates faults, to help reduce the number of utility customers affected by outages, and to enable faster repairs and service restoration.

- An advanced monitoring control system, designed to dynamically control capacitors to boost voltage only where and when it's needed. Smarter control of the distribution system helps save electricity.
- Advanced battery storage devices, which can inject or withdraw power from the grid at appropriate times to smooth out variations in load and generation output. This helps maintain the stability of a local distribution system as it incorporates power from intermittent sources (such as solar or wind power), or as it accommodates an influx of electric vehicles (see "Energy Storage," below).

SCE's Advanced Technology Lab is a hub for smart grid, energy storage and other research.

As of December 31, 2013,

20,000 +

electric vehicles registered in SCE territory

Electricity: A Transportation Fuel More Customers are Choosing

SCE estimates that customers registered about 20,000 plug-in electric vehicles (PEVs) by year-end 2013, a 140 percent increase year over year. SCE has continued to work closely with stakeholder groups and the cities we serve to be plug-in ready: Virtually all of the 180 cities in SCE's service territory are committed to helping their residents by streamlining permitting processes for any electricity upgrades and building charging infrastructure.

In August 2013, SCE released a white paper analyzing insights collected from its PEV readiness efforts, entitled, **"Charged Up: Southern California Edison's Key Learnings about Electric Vehicles, Our Customers and Grid Reliability."**

SCE's Electric Vehicle Tech Center tests technologies like plug-in hybrids and fast chargers.

Among the paper's key findings:

- SCE's approach to managing PEV-grid impact through its regular infrastructure upgrade and maintenance schedule appears to meet customer needs. Less than 1 percent of the nearly 400 upgrades since 2010 to circuits serving PEV customers were because of the PEV's additional power demands.
- It's better for grid reliability and neighborhood circuits when EV drivers program their charging to be complete by a specific time. By doing so, they randomize the start time of their charging, which prevents a large number of vehicles from coming online at the same time.
- When customers visit SCE's PEV website, their most popular first stop is a tool that helps estimate charging costs. Customers also click to find out more about public charging station locations, watch videos on PEVs, and read background materials on environmental benefits and home electric infrastructure requirements.
- Multi-unit residents may face complex challenges: Fewer than 5 percent of building owners or condominium associations are even considering installing the necessary infrastructure.

At the time of the report's publication, about 10 percent of national EV sales and leases occurred in SCE territory, giving the company broad experience to share with other utilities, the auto industry, and other stakeholders.

Investing in Energy Storage

SCE is currently supporting several ongoing energy storage demonstrations and pilots, including and beyond ISGD (see above). SCE's Tehachapi Energy Storage Project is evaluating a utility-scale, lithium-ion battery system to improve transmission grid performance and integration of large-scale, variable energy resources such as wind and solar.

SCE is also deploying distributed energy storage systems on SCE's distribution circuits throughout the region, including residential energy storage units and a larger energy storage system that is part of a load shifting project for commercial customers. All together, SCE's energy storage research covers every point along the power delivery value chain – transmission, distribution substation, workplace, neighborhood and individual residences.

In addition, SCE's Advanced Technology group works closely with major battery manufacturers to evaluate their products.

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SCE has performed a significant number of battery tests throughout the last 15 years to characterize the performance and lifetime of each vendor's technology.

In October 2013, the California Public Utilities Commission (CPUC) unanimously approved a mandate that requires the state's three investor-owned utilities to add 1.3 gigawatts of energy storage to their grids by the end of 2020. SCE has submitted an application seeking approval of its plan, which includes efforts to increase the number of batteries, thermal energy storage and other forms of energy capture-and-release technologies on the grid.

Improving Outage Response

SCE completed the deployment of five million new SmartConnect™ smart meters for households and small businesses in 2012. In 2013, SCE began integrating data from the smart meters' outage notifications into our existing Outage Management System to help us improve our outage response.

The meters provide nearly real-time information to our Grid Operations team when customers lose their power or when their power is restored. This information is also provided to SCE.com's Outage Map, so customers can see outage size and location online.

The smart meter functionality also allows SCE to perform over-the-air voltage reads at an individual customer level. SCE extended this voltage read capability to our Customer Call Center representatives in February 2014 to provide a better customer experience.

California: At the Vanguard of Developing the Next Generation Grid

In October 2013, California Governor Jerry Brown signed AB 327 into law, a bill that addresses several topics important to developing the next generation grid and distributed energy resources. The CPUC is the agency responsible for implementing the new law and has open dockets to address many of the provisions, which include:

- Rate regulation: AB 327 provides a path for the CPUC to amend the complex, tiered rate structure for residential customers to ensure more equitable distribution of electricity costs through fair rates and regulations.
- Renewable resources: Because of AB 327, the Commission can now create programs to advance the development of renewable resources beyond the 33 percent state goal.
- Net metering: AB 327 extends the Net Energy Metering program and authorizes the CPUC to develop new rules for how customers are paid for power they export to the grid and how they pay their share of maintaining the grid. All electricity customers, even solar users, use the power network, so everyone should pay for it.
- Distribution resource plan: AB 327 requires the utilities to submit a distribution resource plan to the CPUC in June 2015 that details how utilities are working to make clean, distributed energy resources more feasible options for homes and businesses.

SCE's Tehachapi Energy Storage Project.

Empowered Customers

Customer Engagement and Social Media

SCE continues to inform and engage customers through Twitter, Facebook, Instagram and other social media channels on important issues such as electrical safety, managing their bills, outage information and energy efficiency.

SCE's Facebook site gained 21,000 new followers in 2013 and reached an average of 801,000 people each month. SCE's Instagram account, where SCE employees and customers share photos and related information to increase customer engagement, grew by more than 1,300 percent and posted 323 photos of relevant information.

SCE's Facebook site reached an average of 801,000 people each month in 2013

Social Media

Twitter

↑ **7,980** New Followers in 2013

↑ **89%**

Facebook

↑ **21k** New Followers in 2013

↑ **801k** People reached each month in 2013

Instagram

↑ **1300%** New Followers in 2013

↑ **323** New photos of relevant information

SCE's Twitter account (@SCE) showed strong growth in 2013. Customers have used it as a resource, especially for outage and emergency communications. The account grew by 7,980 followers in 2013, an 89 percent increase. The value was illustrated in August 2013 when 120,000 customers lost power in Visalia, Calif., and @SCE became a primary source of information. The constant stream of information from @SCE and personalized engagement with customers filled a need that SCE was well positioned to deliver. There were more than 1,000 mentions overnight from customers and 995 new followers. SCE's social media team earned a PR News "Icon" Award for Crisis Communication for its actions during the outage.

Energy Affordability

For families who may be struggling to pay their bills, SCE offers CPUC-authorized programs to customers with qualifying incomes. The California Alternate Rates for Energy (CARE) or Family Electric Rate Assistance (FERA) programs offer ongoing bill support. The Energy Savings Assistance (ESA) Program can help save money over time by covering the cost and installation of efficient new appliances.

As of December 2013, more than 1.3 million SCE customer accounts — more than one quarter of SCE's customer base — were enrolled in CARE, and more than 25,000 households were participating in FERA. More than 69,000 homes made use of the ESA program, saving more than 31 million kilowatt-hours and reducing demand by 12,596 kW in the process.

Through Edison International's Energy Assistance Fund (EAF), administered by the United Way, qualifying SCE customers can receive up to $100 toward their energy bill once in a 12-month period. In 2013, our employees, customers and Edison International shareholders donated more than $1.5 million, which assisted 14,131 households.

Offering Customers Options to Save Energy and Money

In 2013, SCE partnered with customers to deliver 1,744 GWh in energy savings (124 percent of the goal established by the CPUC) and 193 MW of long-term peak demand reduction (106 percent of goal). These energy efficiency savings helped to prevent the release of roughly 490,000 metric tons of greenhouse gas (GHG) emissions into the atmosphere, which is equivalent to removing 102,000 cars from the road for an entire year, and supports the state's GHG reduction goals.

Over the past five years, our customers have saved more than 8.3 billion kWh of electricity by participating in our energy-efficiency programs. These savings are enough to power nearly 1.2 million California homes for an entire year. At the same time, they have reduced GHG emissions by nearly 3.6 million metric tons — the equivalent of removing 743,000 cars from California's roads.

In 2013, SCE's portfolio of demand response programs included more than 1,200 MW in eligible resources to reduce electricity use any time it was needed. We have more than 19,000 businesses and 650,000 households that participate in our demand response programs.

One popular SCE demand response program, the Summer Discount Plan, lets participants earn up to $200 in bill credits over the summer by allowing SCE to remotely turn off (or "cycle") their air conditioner as needed. Customers can

SCE customers saved

8.3 Billion

kWh via energy efficiency over the last five years

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choose their incentive level by deciding how often — and for how long — they permit us to cycle their air conditioner during SDP events. In 2013, more than 25,000 new enrollments pushed total participation to more than 316,000 customer accounts, resulting in 41.53 MW of energy savings.

On any weekday when electricity demand is relatively high, SCE can call a Save Power Days "event" between 2 to 6 p.m. asking customers to conserve electricity. All SCE customers enrolled in Save Power Days can earn up to $0.75 for every kilowatt hour reduced during the event (based on the customer's average weekday usage from 2-6 p.m.). SCE customers who own a compatible communicating thermostat can earn an additional $0.50, for a total of $1.25, for every kilowatt hour saved.

A continuing study by SCE is examining the use of programmable, communicating thermostat technology paired with SCE's Save Power Days demand response program. SCE partnered with technology companies Alarm.com, EnergyHub, and Nest Labs to conduct the research.

Approximately 2,800 customers enrolled in the study during Summer 2013, when SCE called five Save Power Days events. The study resulted in more than 20 MWh of energy reduction over the course of those five events, according to third party validation. The average savings was about 3.0 kWh per household, or about 0.75 kilowatts per hour – which would translate into an average bill credit of about $45-50 during an average season.

About

300,000

homes participated in SCE's 2013 Save Power Day events

Lowering shades is one way to save energy when SCE calls a Save Power Day.

Overall, approximately 300,000 homes in SCE territory participated in each of 2013's Save Power Days events, resulting in about 25 MW in total energy savings.

Statewide Energy Saving Initiatives

SCE continued its participation in Energy Upgrade California™, a state initiative to help communities meet state and local energy and climate action goals. It encourages Californians to reduce demand on the electricity grid, make informed energy management choices at home and work, and conserve natural resources. It is supported by an alliance of the CPUC, the California Energy

In 2013,
SCE customers installed

147.5 MW

of solar power
with incentives from the
California Solar Initiative

Commission, utilities, regional energy networks, local governments, businesses, and nonprofits. Funding comes from customers of the state's three investor-owned utilities (IOUs) under the auspices of the CPUC. SCE's share is 33.45 percent; in 2013, SCE's customers provided $1.75 million to the initiative.

Flex Alert is another statewide initiative funded by customers of the state's IOUs. A Flex Alert is an urgent call to cut back on electricity and shift demand to off-peak hours (after 6 pm). Flex Alerts inform consumers about how and when to conserve electricity. The media effort is critical to achieve high levels of conservation during heat waves and other challenging grid conditions. SCE's contribution is 60 percent – $6 million in 2013 – since there is a greater demand in its territory during the hot summer months. SCE supplemented the statewide media effort with local outreach using community and faith-based organizations. An incremental $175,000 was utilized to fund the local activity.

Growing Solar

One key to meeting customers' energy needs is using multiple sources of energy, and solar is one of those critical sources.

According to the Solar Electric Power Association, SCE ranked second among utilities nationwide in 2013 for the number of new solar customer interconnections, bringing 26,372 customer systems into the grid. That's a new solar customer interconnection every 20 minutes.

The California Solar Initiative (CSI) is a ratepayer-funded program that pays an incentive to customers who install photovoltaic or solar thermal systems on their homes or businesses. In 2013, SCE paid customers to install 15,120 distributed generation solar projects for 147.5 MW. Since the CSI's inception in 2007 through the end of 2013, SCE has paid customers for a total of 45,326 projects; the system total of these projects is 474.2 MW.

SCE regularly offers workshops for homeowners, businesses, government and nonprofit customers. In 2013, we conducted 12 commercial workshops, six contractor classes, 27 homeowner solar classes, 19 solar connection events, and four solar thermal trainings. The classes and events provide attendees with a high-level overview of the CSI program, how to go solar, and how to determine whether going solar is right for their home, business, or organization.

Customer Satisfaction

Among large utilities in the West, SCE was ranked fifth in customer satisfaction by residential customers (same as the previous year) and seventh by Business customers (down from fourth the previous year), according to the J.D. Power and Associates 2014 Residential and 2014 Business Electric Utility Customer Satisfaction Studies. The drop in business customer ranking is attributed to SCE maintaining its satisfaction level while comparable utilities improved their scores.

Healthy Environment

California is a national leader in designing policies that enhance environmental sustainability. SCE is committed to protecting the environment; we know that protecting and responsibly managing the natural resources entrusted to our care are vital to the environment and the quality of life in the communities we serve.

Volunteers plant trees at Amigos de los Rios event funded in part by Edison International.

In 2013, SCE delivered

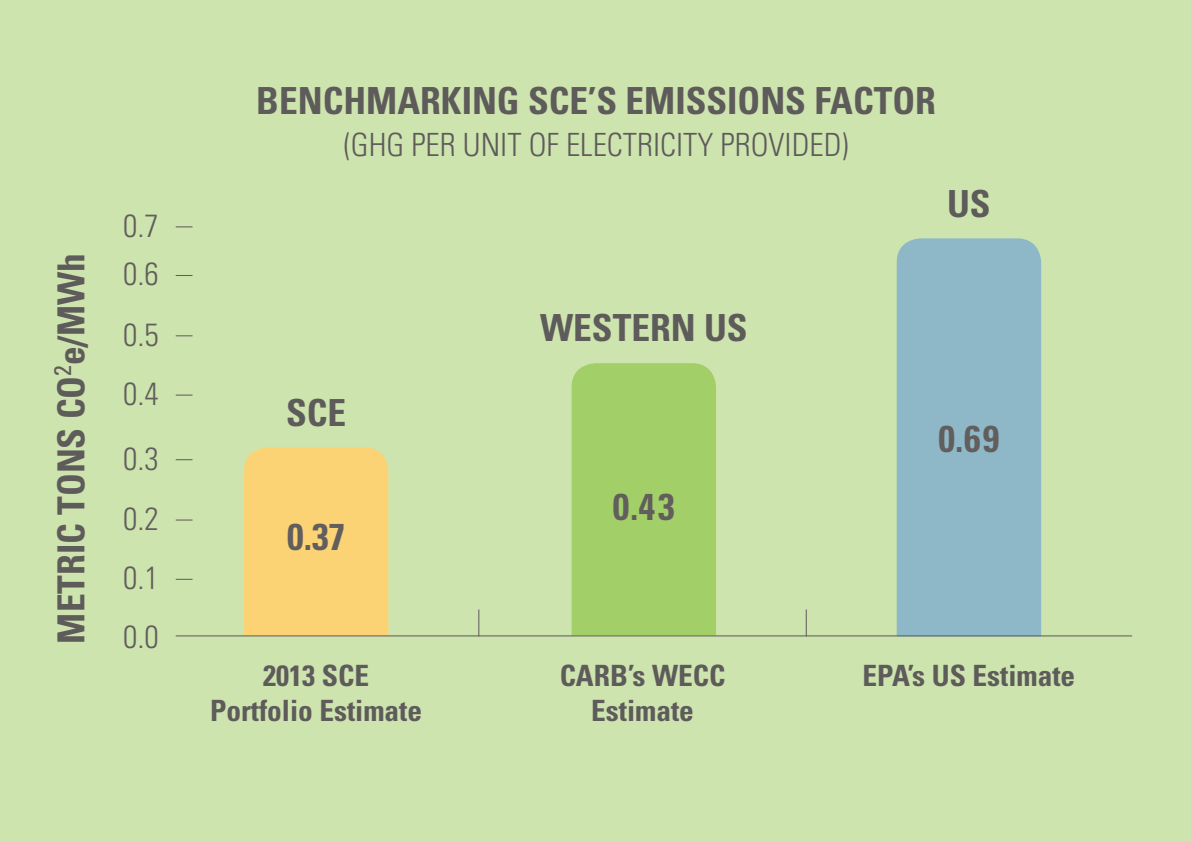
1.06 Million

MWh of solar energy to customers from owned and purchased sources

Global Climate Change

SCE believes that addressing global climate change is an important issue. We support the state's efforts to reduce greenhouse (GHG) emissions and are committed to meeting our obligations under the California Global Warming Solutions Act. In addition, we welcome the opportunity to work with the U.S. Environmental Protection Agency, the administration and Congress to develop federal policies that would align with California's programs and reduce GHGs without adversely affecting our ability to provide reliable and affordable electricity to our customers.

Since 2012, SCE has produced a comprehensive accounting of its GHG emissions. SCE's GHG intensity per unit of electricity served remains well below the estimated national and western U.S. averages.



Four Corners Power Plant

In December 2013, SCE completed the sale of its 48 percent interest in Units 4 and 5 of the Four Corners Power Plant to Arizona Public Service Company (APS). Approval for the sale had been granted in 2012 by the CPUC and the Arizona Corporation Commission. With the completion of the sale, SCE no longer owns any coal-fired generation. The sale has been incorporated into long-term reliability planning, and SCE will be buying power that will be significantly lower in GHG emissions.

SCE-supported solar carport project in Long Beach

Renewable Energy

California has a number of policies to promote renewable energy. In 2013, renewable energy resources made up 21.6 percent of the electricity SCE delivered to customers, including:

- 16,061,796 MWh purchased to meet the state's renewable energy goals
- 381,912 MWh of hydropower energy (SCE-owned and purchased from other providers)
- 1,037,020 MWh of solar energy (SCE-owned and purchased)
- 7,518,081 MWh of wind energy (purchased)
- 6,640,784 MWh of geothermal energy (purchased)
- 483,999 MWh of biopower energy (purchased)

Transmission Projects For Renewable Energy

Meeting the state's renewable energy goals means SCE must build new high-voltage transmission lines or upgrade existing lines.

- SCE completed construction in 2013 on the 153-mile Devers-Colorado River (DCR) and 35-mile Eldorado-Ivanpah (EITP) Transmission Projects. The EITP project can now deliver up to 1,400 MW of power from renewable and traditional generating sources, and DCR can accommodate up to 2,300 MW, once the West of Devers upgrade is completed.
- SCE is building the 173-mile Tehachapi Renewable Transmission Project Segments 4-11, part of the nation's largest transmission project devoted primarily to renewable energy. It will deliver up to 4,500 MW of power to California's grid — enough to power 3 million homes.
- SCE's Coolwater-Lugo Transmission Project and the West of Devers Upgrade Project have been filed for licensing. If approved, they will add up to 1,000 and 3,200 MW, respectively, of additional transmission capacity for future, renewable generation being developed in Riverside and San Bernardino counties and the Imperial Valley.

Some of the Red Bluff Substation Project will help SCE connect future renewable power projects in eastern Riverside County to our transmission grid.

Solar Decathlon

The ABC Green Home, the certified, net-zero energy home created by SCE and *Green Homebuilder* magazine, was showcased at the U.S. Department of Energy's 2013 Solar Decathlon.

At the close of the Decathlon, the ABC Green Home received the Innovative House of the Year award presented by The Greater Sales & Marketing Council and Building Industry Association at the SOCAL Awards.

In collaboration with Habitat for Humanity, plans are in place to replicate an exact model of the ABC Green Home in 2014 to provide a residence for the family of a disabled veteran.

A biennial event, the Solar Decathlon challenges 20 student teams to design, build and operate solar-powered houses that are cost-effective, energy efficient and attractive.

Edison International was a Sustaining Sponsor of the 2013 Solar Decathlon. The event aims to educate students and the public about the benefits of clean-energy products and designs, demonstrate the comfort and affordability of living in homes that combine energy efficiency with renewable energy systems, and help prepare students to enter our nation's clean-energy workforce.

The ABC Green Home, created by SCE and Green Homebuilder magazine, at the 2013 Solar Decathlon.

Amigos de los Rios

A 2013 grant of $50,000 by SCE's parent company, Edison International, to the nonprofit Amigos de los Rios helped fund an event where more than 200 volunteers planted 150 trees at a local park in the city of South Gate. SCE donated the trees from its Auberry Tree Farm near Shaver Lake in the Central Sierras. SCE has partnered with Amigos de los Rios for ten years to help the group's efforts to protect and restore green spaces such as parks and trails in East Los Angeles County. SCE supports tree planting and healthy forest activities, doing our part to offset global deforestation that contributes to more than 25 percent of worldwide GHG emissions each year.

Water-related usage consumes nearly

20%

of California's electricity

Source: California Energy Commission, www.energy.ca.gov/research/iaw/water.html

Hydropower and Water Use

In a normal year, SCE's hydropower systems generate enough emission-free electricity to power approximately 640,000 homes (~4,400,000 MWh). Ongoing severe drought conditions in California directly impact SCE hydropower operations and how SCE customers are doing business – especially agricultural customers.

During this unprecedented drought, SCE will continue to safely operate our hydropower systems in a manner that considers fish and wildlife, water for downstream users, and recreational opportunities. SCE is in communication with various federal and state agencies (CPUC, CEC, CAISO and FERC) on the forecasted impacts of the drought on our hydropower operations. SCE is also in communication with federal and state agencies on the status of our reservoirs and our forecasted water supplies for various downstream uses and fish and wildlife habitat.

Water-related energy use in agricultural, commercial, industrial, and residential sectors consumes nearly 20 percent of the state's electricity. Therefore, reducing

water consumption will not only support state-wide water conservation efforts, but will also help reduce electricity usage in California. For SCE's customers, water conveyance, treatment, and irrigation contribute to a significant amount of energy usage, which is increasing with the drought as water deliveries are curtailed and water agencies need to pump more groundwater.

SCE offers energy efficiency and demand response programs that can lower energy consumption and manage costs for customers. Those programs are available at **http://www.sce.com/water**.

Water Efficiency at SCE Facilities

SCE has been reducing our water use through appropriate facility management across the service territory. At SCE's General Office buildings, we are using recycled/reclaimed water to meet our landscape irrigation needs. Additionally, over the past several years, SCE has installed drought-tolerant landscapes at various SCE sites. Each of these sites had a minimum of 60 percent water reduction.

SCE has performed facilities upgrades to ensure new construction standards are met, including installing low-flush toilets, auto/low-flow faucets, and low-flow shower heads. All major building renovations and new construction projects are targeted to attain LEED (Leadership in Energy and Environmental Design) certification from the U.S. Green Building Council.

Other SCE facilities employ even more sophisticated methods to save water. For example, operations at our Mountainview power plant in Redlands use water that is unfit for drinking, so it doesn't go to waste. Approximately 50 percent of the water needed to run this water-cooled power plant is non-drinkable wastewater from the City of Redlands. The remainder is non-drinkable water from an underground aquifer.

In addition, the Mountainview onsite water treatment system allows the plant to recover and recycle 80 percent of the water that is used by the cooling process. The remaining percentage is treated and transported into the ocean as harmless salt water.

SCE's Mountainview power plant recovers and recycles 80 percent of the water used in its cooling process.

Members of SCE's Latinos for Engagement, Advancement & Development (LEAD) employee resource group, (l-r) Hector Aguilar, Jeannine Villasenor, Chris Rivas and Kaylen Malley.

First-Rate Workforce

SCE's employees are the company's most important asset. A healthy, diverse and well-trained workforce is essential to achieving operational and service excellence.

Workforce Diversity

Our ability to attract and retain a diverse workforce allows us to leverage their unique experiences, better reflect the communities we serve, and raise cross-cultural awareness that benefits both the company and its customers. This is particularly important as about one

Workforce Statistics

		12/31/2011	12/31/2012	12/31/2013
Full-time employees		18,057	16,515	13,654
Collective bargaining unit/union members (pct. of workforce)		31%	30%	29%
SCE Workforce Diversity (pct. of workforce)	White	46%	46%	43%
	African-American	8%	8%	8%
	Hispanic/Latino	29%	29%	31%
	Asian	13%	13%	14%
	American Indian/ Alaskan Native	1%	1%	1%
	Pacific Islander/ Native Hawaiian	< 1%	< 1%	< 1%
	Two or more races	2%	2%	2%
Minorities as pct. of workforce		54%	54%	57%
Minorities as pct. of management		50%	51%	53%
Females as pct. of workforce		31%	32%	33%
Females as pct. of management		33%	34%	34%
Pct. of employees eligible to retire in 10 years		33%	35%	33%

Roundtable, an SCE employee resource group, teams up with Girls Inc. of Orange County to change the lives of girls through STEM programs.

third of our employees are eligible to retire in the next 10 years, and a younger generation enters the SCE workforce. In 2013:

- 64 percent of our new hires were ethnic minorities
- 44 percent of our elected officers were ethnic minorities or women
- 38 percent of our board of directors were ethnic minorities or women

The diverse mix of employees has steadily grown over time. For example, the percentage of nonwhite employees has increased from 49 percent in 2006 to 57 percent in 2013.

With an ever-changing canvas to our employee population, SCE has taken steps to include learning modules on diversity and inclusion in all leadership training programs. Leadership assessments were also conducted for all executives, managers and supervisors in 2013. Part of the assessment included a section that confirmed leaders' commitment to lead an organization that is diverse and inclusive.

Talent recruiters have been trained to work with hiring managers to ensure that all qualified candidates are considered for positions at SCE.

Employee Resource Groups

There are currently 14 Employee Resource Groups (ERGs) at SCE, representing a range of cultures, generations, ethnic groups, sexual orientations, and those focused on issues such as employee safety and the environment. ERGs are a committed group of employees, volunteering to dedicate their time outside of work hours to promote and embrace diversity and inclusion within the company.

Some ERGs host signature celebrations focusing on cultural events or workplace issues to promote awareness, while also raising money for nonprofits aligned with their mission and purpose.

In October 2013, SCE was recognized as one of the top 10 companies for employee resource groups at the 2013 National ERG Summit in National Harbor, Md. In partnership with California State University-Fullerton, and the University

Mario Ang, member of SCE's FilBarkada employee resource group, with relief supplies for victims of the Philippines' Typhoon Haiyan.

of California-Riverside, Upward Synergy conducted a study to identify the best companies for ERGs in 2013. Companies were evaluated for their support of ERGs, as well as best practices and innovation. SCE ranked fifth out of the 10 companies recognized.

57%

of SCE's workforce are ethnic minorities

Ethics and Compliance

Our long-term success rests on our employees accepting personal accountability for living the company values and complying with company policies and applicable laws, rules and regulations. At SCE, compliance is not just honoring the letter of the law, but also working to live up to the spirit of the law.

Our Ethics and Compliance Code defines expectations of ethical behavior in specific workplace situations and helps employees find additional guidance when needed to address any questions and concerns. SCE assures compliance with the Ethics and Compliance Code through required annual employee training. In 2013, 99 percent of our non-represented employees certified their compliance with our Ethics and Compliance Code, and 99 percent of non-management employees completed Ethics and Compliance training.

SCE expects all company leaders to set an ethical tone and solicit employee feedback. Leadership training helps managers and supervisors foster a culture of trust and accountability in their workgroups.

Edison HelpLine (1-800-877-7089)

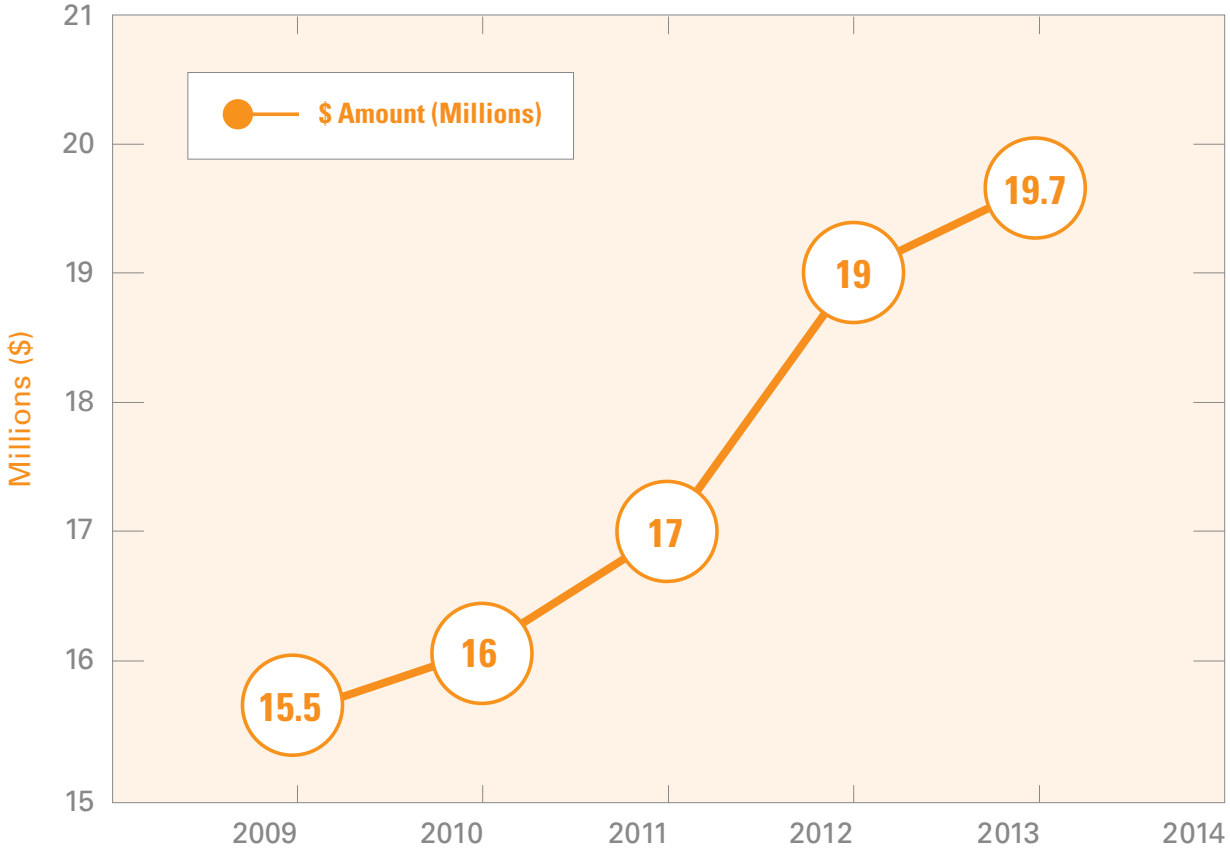
Our employees are encouraged to raise issues, seek advice, and report ethics, compliance, employee relations, work environment or non-emergency security concerns so they may be addressed promptly. In addition to discussing and resolving issues with their managers or supervisors, employees may report online or call the Edison HelpLine. When using the helpline, employees can choose to identify themselves or remain anonymous. SCE absolutely prohibits retaliation.

In 2013, our Edison HelpLine received 1,412 contacts, of which 71 percent reported Ethics and Compliance Code concerns (such as discrimination, sexual harassment, or conflict of interest), and 18 percent sought advice on matters related to employment, conflicts of interest or misuse of company resources.

As of December 31, 2013, 44 percent of all contacts were assigned for investigation. Of the concerns investigated and closed, 22 percent were substantiated. At year-end, all concerns in 2013 were not fully settled and will continue being handled in 2014. Total contacts rose 26 percent and the rate of anonymous reporting decreased by 3 percent from 2012.

Strong Communities

The company and its employees invest time and money in the neighborhoods we serve to help build strong communities, and SCE partners with our communities to create new opportunities for growth. We know that we are only as strong as the people we serve.



Shareholder contributions to Edison International's community investment funding

Edison International employees donated

$2.9 Million

to charitable causes in 2013

Community Investment

Over the past five years, Edison International's annual community investment funding from shareholders has been increasing steadily from $15.5 million in 2009 to $19.7 million in 2013. Since the company's target for giving is 1 percent of pre-tax earnings from operations, this increase corresponds to SCE's steady growth. Customer funds are not used for community investment.

Employee Volunteerism

On any given Saturday, southern, central and coastal Californians are likely to see groups of Edison International employees in their green T-shirts volunteering in their communities. SCE's culture of giving back drives our corporate philanthropic efforts. For generations, our employees have embraced this culture of giving and have contributed their time and money to a variety of nonprofit organizations and social causes that benefit children, the elderly, veterans, the disabled, and low-income families.

In 2013, our employees raised $2.9 million through employee-initiated fundraising drives and our annual Employee Contributions Campaign, an inspirational tradition that allows employees to make personal contributions to nonprofits and schools.

Edison International employees also volunteered 281,112 hours, worth an estimated $6.2 million, to a variety of community projects. These activities ranged from company-wide events with the California State Parks Foundation and the Orange County Regional Food Bank to our annual Season of Service campaign, which encourages employees to volunteer with local nonprofits.

Edison International employees contributed an estimated $6.2 million worth of volunteer hours in 2013.

In 2013,

281,112

hours of volunteer work by Edison International employees and retirees

During our fifth annual Season of Service, employees were encouraged to volunteer in a number of activities sponsored by our various Employee Resources Groups (ERGs) and that benefit multiple nonprofits in our service territory. At the end of the campaign, each of our 14 ERGs had the option of designating a $5,000 corporate contribution grant to a partnering nonprofit organization that is aligned with our corporate giving priority areas (Education, Environment, Engagement, Public Safety & Preparedness).

Edison Scholars for 2013 included (l-r): Jasmine Esparza, Jeff Wettstein, Chika Okonkwo and Alexander Chan.

Edison Scholars

In 2013, 30 high school graduates received $40,000 college scholarships through the Edison Scholars Program, which offers scholarships to underserved students desiring higher education in the science, technology, engineering, and math (STEM) fields. It helps fill a need for STEM professionals to preserve our country's leadership in science and technology and supports our company's workforce development.

The Edison Scholars Program is administered by Scholarship America, an organization focused on mobilizing scholarship and educational support to make post-secondary studies possible for all students.

Supplier Diversity

In the last 35 years, SCE has spent $13 billion with diverse firms as part of its Supplier Diversity program. Since 2009, SCE's spending with diverse business enterprises (DBEs) has increased 97 percent and continues to exceed the CPUC target of 21.5 percent. In 2011, SCE President Ron Litzinger set an aspirational goal of 40 percent spending with DBE firms by 2016. SCE exceeded that goal in 2013 — well ahead of the targeted year — resulting in 41 percent of its procurement spend with over 800 diverse businesses.

In addition, SCE encourages its prime suppliers to subcontract a portion of all contracts valued at $250,000 and above to woman-owned, minority, service-disabled veteran business enterprises (WMDVBE). In 2013, spend with diverse subcontractors — Tier 2 suppliers — grew to $542 million (37.8 percent of total spend), nearly a 10 percent increase from 2012. This increase is attributed to SCE's targeted activities to increase subcontracting spend with diverse firms.

SCE Supplier Diversity Spend

	2011	2012	2013
Tier 1 Suppliers ($ millions)	$970	$1.0 B	$894
Tier 2 Suppliers ($ millions)	$428	$498	$542

SCE strives to expand diversity spend beyond ethnicity and gender. We will continue identifying and expanding our footprint in other diverse and underserved communities. In 2013, SCE became a corporate member of the National Gay and Lesbian Chamber of Commerce.

In the last 35 years,

$13 Billion

spent with diverse firms through SCE's Supplier Diversity program

SONGS Community Outreach

Since the decision to shut down the San Onofre Nuclear Generating Station (SONGS) in June 2013, SCE's outreach has focused on helping public officials and the community understand the decommissioning process and the steps the company will be taking to ensure we proceed in a manner that protects the health and safety of the public while engaging the community.

In 2014, The SONGS Community Engagement Panel (CEP) was created by the SONGS co-owners as a volunteer, non-regulatory body to enhance and foster open communication, public involvement and education on SONGS decommissioning activities. It is intended to serve as a conduit for public information and encourage community involvement and communication with the SONGS co-owners on matters related to SONGS decommissioning.

Community Forums and Speakers Bureau

SCE hosts community forums to provide helpful information about our programs and initiatives to leaders of community-based organizations and nonprofits who then share the information with their constituents. During these day-long events, almost 450 organizations benefitted from presentations by SCE representatives on: electrical safety; Edison International's philanthropic grant programs; and income-qualified programs such as California Alternate Rates for Energy, Family Electric Rate Assistance and our Energy Assistance Fund.

Throughout the year, SCE hosted seven "Helping our Customers Succeed" Community Forums targeting the Latino, African American, Native American, and Pacific Islander populations. These Forums provide a wealth of information on programs and services available to customers, businesses, and non-profit organizations. This strategy builds program awareness at a grassroots and community level where many income-qualified households may connect.

SCE's Speakers' Bureau is a labor of love. Employee volunteers speak to various audiences across our service territory to make presentations that educate customers and community groups on electrical safety, energy efficiency, SCE customer programs and other important topics. Because our communities are diverse, the presentations are made in multiple languages. In 2013, our Speakers' Bureau ambassadors made 300 presentations.

The SONGS Community Engagement Panel fosters open communication, as well as public involvement and education about the plant's decommissioning.

377

Company	2011	2012	2013	National Average
Safety: Employee OSHA Recordable Rate	4	3.65	3.42	—
Safety: Employee Lost Workday Case Rate	1.59	1.22	1.08	—
Safety-related Internal Compliance Assessments and Audits	5	8	11	—
Women in the Workforce	31%	32%	33%	31%
Minorities in the Workforce	54%	54%	57%	27%
Women in Management	33%	34%	34%	—
Ethnic Diversity in management	50%	51%	53%	—
Supplier Diversity Spend rate	33.7%	38.2%	41%	40%
Ethics and Compliance Helpline contacts	n/a	1,172	1,412	—
Edison International Net Income (millions)	($37)	($183)	$915	—
Edison International Basic Earnings per Share	($0.11)	($0.56)	2.81	—

Customers	2011	2012	2013	National Average
Customer Satisfaction: J.D. Power & Associates Survey Results - Electric Residential	650	655	667	639
Customer Satisfaction: J.D. Power & Associates Survey Results - Electric Business	661	679	670	647
System Reliability: SAIFI (Interruptions)	0.91	0.86	0.88	1.08
System Reliability: SAIDI (Minutes)	108.2	100.7	94.48	126
System Reliability: MAIFI (Interruptions)	1.36	1.35	1.18	—

Communities	2011	2012	2013	National Average
Employee & retiree volunteer hours	250,000	240,000	281,112	—
Contributions to nonprofits by employees (millions)	$4.2	$3.9	$2.9	—
Community Investments: Pre-Tax earnings from Operations (millions)	$17.0	$19.2	$19.7	—

Environment	2011	2012	2013	Nat. Avg.
Customer Energy Efficiency: GWh % of CPUC Goals	166%	160%	124%	--
Customer Energy Efficiency: MW % of CPUC Goals	142%	132%	106%	--
Customer Demand Response (MW)	--	1,300	1,200	--
Renewables Portfolio Standard: Eligible Renewables	20.8%	20.6%	21.6%	--
CO2e Emissions from Owned Electricity Rate (lbs/MWh)	397	753	777	1216
CO2e Emissions from Delivered Electricity Rate (lbs/MWh)	517	705	805	1216
Scope 1 Emissions (million metric tons CO2e)	6.3	7.2	6.2	--
Scope 2 Emissions (million metric tons CO2e)	1.0	1.5	2.0	--
Scope 3 Emissions (million metric tons CO2e)	12.4	16.9	21.6	--
SF6 Emissions Rate	0.90%	0.64%	0.62%	--
SF6 Emissions (metric tons)	3.247	2.463	2.621	--
NOx Emissions Rate of UOG (lbs/MWh)	0.660	1.160	1.30	1.10
NOx Emissions from Power generation (metric tons)	13811.69	35723.6	9997.8	--
SO2 Emissions Rate of UOG (lbs/MWh)	0.250	0.370	0.420	2.10
SO2 Emissions from Power generation (tons)	4186.95	10123.3	3213.3	--
Hazardous waste (tons)	--	--	29,328.04	--
Agency inspections	304	459	474	--
Notices of Violation (NOV)	31	54	15	--
Inspections with No NOVs Issued (% of total inspections)	90%	88%	97%	--
Settlement, Fines and Penalties	$19,900	$2,000,600	$10,785	--
Environmental-related Internal Compliance Assessments and Audits	5	10	9	

The metrics displayed here were selected as indicators of economic, environmental and social performance by the California Utility Sustainability Partnership (CUSP), comprised of representatives from the state's investor-owned utilities.

Corrections

The Scorecard in the SCE's 2012 Corporate Responsibility & Sustainability Report listed incorrect figures for Employee Lost Workday Case Rate for the years 2011 and 2012. The correct rate for 2011 was 1.59, not 2.37. The correct rate for 2012 was 1.22, not 1.82. The rates appear correctly in this year's Scorecard.

Definitions

Scope 1 - Emissions under the direct control of the company including Utility Owned Generation (UOG), Transportation, SF6 from T&D equipment
Scope 2 - Indirect emissions required for business processes including Transmission losses, Facility energy use (electricity and natural gas)
Scope 3 - Indirect emissions released as a consequence of the activities of the company including specified power purchases, unspecified power purchases
SAIFI – (**System Average Interruption Frequency Index**) The average number of interruptions that a customer would experience (often measured annually).
SAIDI – (**System Average Interruption Duration Index**) The average outage duration for each customer served (often measured annually).
MAIFI – (**Momentary Average Interruption Frequency Index**) The average number of momentary interruptions that a customer would experience (often measured annually).

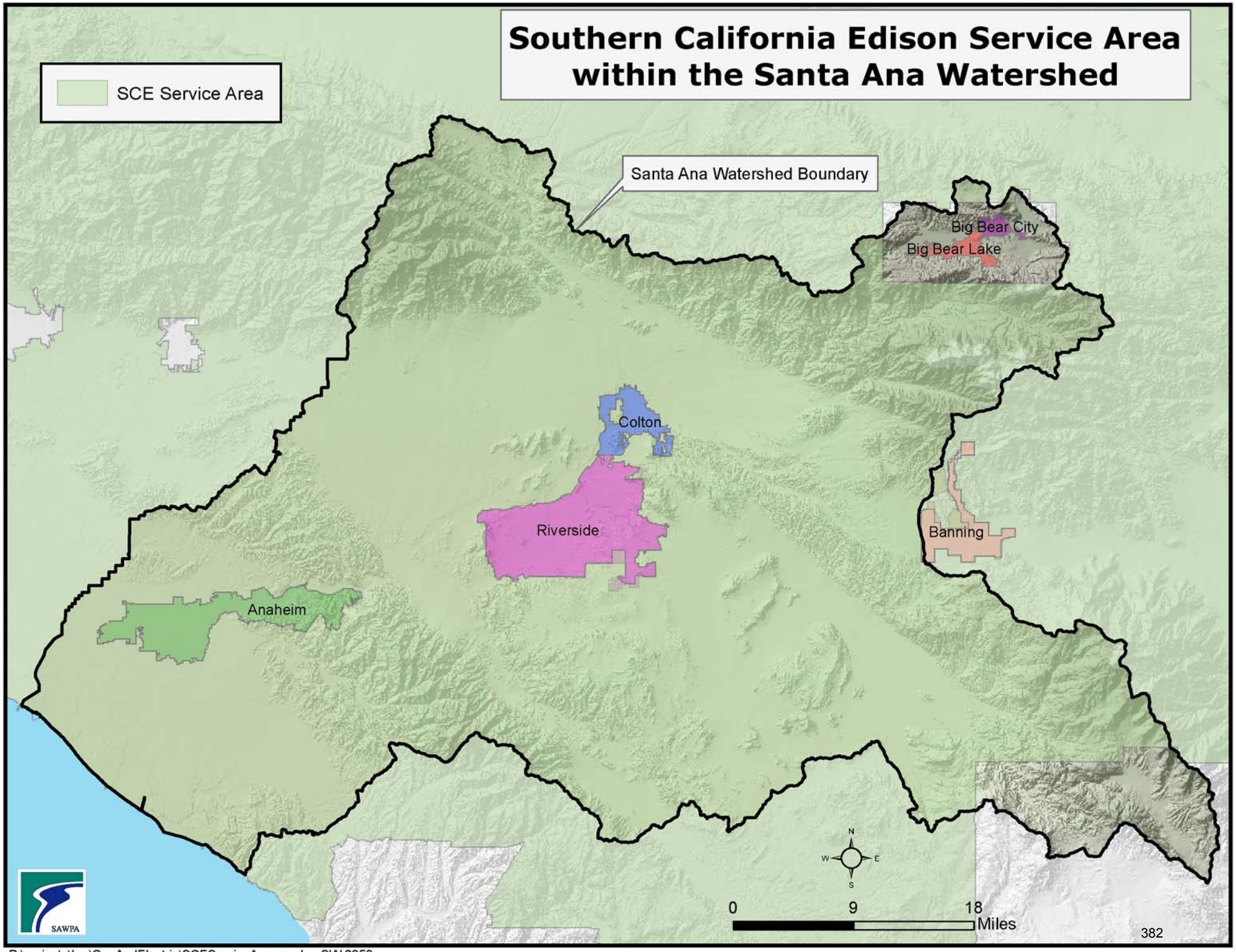
ABOUT THIS REPORT / FORWARD LOOKING STATEMENTS

DISCLOSURES

This report contains "forward-looking statements" within the meaning of the Private Securities Litigation Reform Act of 1995. Forward-looking statements reflect Southern California Edison's current expectations and projections about future events based on Southern California Edison's knowledge of present facts and circumstances and assumptions about future events and include any statement that does not directly relate to a historical or current fact. In this report and elsewhere, the words "expects," "believes," "anticipates," "estimates," "projects," "intends," "plans," "probable," "may," "will," "could," "would," "should," and variations of such words and similar expressions, or discussions of strategy or of plans, are intended to identify forward-looking statements. Such statements necessarily involve risks and uncertainties that could cause actual results to differ materially from those anticipated.

Some of the risks and uncertainties that could cause actual results to differ materially from those anticipated are discussed under the heading "Risk Factors" and "Management's Discussion and Analysis" in Southern California Edison's 2013 Form 10-K and subsequent reports filed with the Securities and Exchange Commission and available on www.edison.com. These forward-looking statements represent our expectations only as of the date of this report, and Southern California Edison assumes no duty to update them to reflect new information, events or circumstances.

Document 11



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Document 12

HOME ENERGY SAVER™

HOME ENERGY SAVER
REPORT

Prepared by:
Santa Ana Watershed Project Authority

This report is generated by the Home Energy Saver web-based energy audit tool, developed by the U.S. Department of Energy's Lawrence Berkeley National Laboratory, and can be reached at http://hes.lbl.gov

HOME ENERGY SAVER™

HOUSE CONFIGURATION

General Information

Name or other identifier this home/session : **WE CAN**; User's email address : **iachimore@sawpa.org**; Purpose of this assessment : **Hypothetical analysis**; City : **San Bernardino**; State : **California**; City with most similar climate to modeled house : **Riverside**; Year house was built : **1967**; People living in the house, by the age - 0-5 : **4**; People living in the house, by the age - 6-13 : **1**; People living in the house, by the age - 14-64 : **2**; People living in the house, by the age - 65 plus : **0**;

House Shape Size

Energy Prices

Energy Prices - Electricity : **0.152**; Energy Prices - Piped Natural Gas : **0.990**; Energy Prices - Liquid Propane Gas (LPG) : **2.570**; Energy Prices - Fuel Oil : **2.520**;

Building Design

Foundation or floor insulation : **No/Don't Know**; Attic type : **Unconditioned Attic**; Wall Construction Front : **Wall insulation ewwf03wo**; Does the house have weather-stripping and/or caulking : **No**; Describe windows on each side of house - Front Type : **Double-pane, clear, Aluminum**; Describe windows on each side of house - Front SqFt : **72.00**; Describe windows on each side of house - Back Type : **Double-pane, clear, Aluminum**; Describe windows on each side of house - Back SqFt : **72.00**; Describe windows on each side of house - Left Type : **Double-pane, clear, Aluminum**; Describe windows on each side of house - Left SqFt : **36.00**; Describe windows on each side of house - Right Type : **Double-pane, clear, Aluminum**; Describe windows on each side of house - Rgith SqFt : **36.00**; Stories above ground level : **1**; Roof Insulation level : **R-0**; Type of foundation : **Slab-on-grade Foundation**; Ceiling Insulation level : **R-11 (4-6 inches)**;

Appliances Equipment

Clothes Washer : **Yes**; Number of refrigerators : **1 Refrigerator**; Water heater - year purchased : **See efficiency value**; Water heater - Tank Size : **40**; Water heater - Fuel : **Natural Gas**; Heating equipment - Type : **Central Gas furnace**; Heating equipment - Year purchased : **Do not know / Default**; Cooling equipment - Type : **Central air conditioner**; Cooling equipment - Year Purchased : **Do not know / Default**; Thermal distribution - Duct Location : **Unconditioned attic**; Thermal distribution - Ducts Insulated : **Yes**; Thermal distribution - Boiler pipe insulation : **No/Don't Know**;

HOME ENERGY SAVER™

YEARLY ENERGY COSTS

Providing more details will make your results more accurate.

Existing Home	$1,569
With Upgrades	$1,012

	Total	Heating	Cooling	Hot Water	Large Appliances	Small Appliances	Lighting
Existing Home	$1,569	$433	$236	$171	$313	$196	$220
With Upgrades	$1,012	$146	$80	$149	$221	$196	$220
Savings	**$557**	**$287**	**$156**	**$22**	**$92**	**$0**	**$0**

Important Note: These are initial estimates only, and results may vary. If the owner has not already done so, we strongly recommend that they retain a professional energy auditor to develop a detailed work scope and budget for improving the home. We also recommend the Home Performance with ENERGY STAR program when considering home improvements.

Comparing Results to Home's Utility Bill

HOME ENERGY SAVER™

YEARLY WHOLE HOUSE RESULTS

		Existing Home	With Upgrades	Savings	Percentage Reductions
Whole House	Energy Bill	$1,569	$1,012	**$557**	36%
	Electricity	6,292 kWh	4,099 kWh	**2,193 kWh**	35%
	Natural Gas	619 Therms	394 Therms	**225 Therms**	36%
	Emissions	11,376 CO2	7,302 CO2	**4,074 lb. CO_2**	36%
Heating	Energy Bill	$433	$146	**$287**	66%
	Electricity	413 kWh	132 kWh	**281 kWh**	68%
	Natural Gas	374 Therms	127 Therms	**247 Therms**	66%
	Emissions	4,642 lb. CO_2	1,569 lb. CO_2	**3,073 lb. CO_2**	66%
Cooling	Energy Bill	$236	$80	**$156**	66%
	Electricity	1,551 kWh	528 kWh	**1,023 kWh**	66%
	Emissions	1,022 lb. CO_2	348 lb. CO_2	**674 lb. CO_2**	66%
Hot Water	Energy Bill	$171	$149	**$22**	13%
	Natural Gas	173 Therms	151 Therms	**22 Therms**	13%
	Emissions	2,021 lb. CO_2	1,764 lb. CO_2	**257 lb. CO_2**	13%
Large Appliances	Energy Bill	$313	$221	**$92**	29%
	Electricity	1,593 kWh	704 kWh	**889 kWh**	56%
	Natural Gas	72 Therms	116 Therms	**-44 Therms**	-61%
	Emissions	1,890 lb. CO_2	1,819 lb. CO_2	**71 lb. CO_2**	4%
Small Appliances	Energy Bill	$196	$196	**$0**	0%
	Electricity	1,290 kWh	1,290 kWh	**0 kWh**	0%
	Emissions	850 lb. CO_2	850 lb. CO_2	**0 lb. CO_2**	0%
Lighting	Energy Bill	$220	$220	**$0**	0%
	Electricity	1,445 kWh	1,445 kWh	**0 kWh**	0%
	Emissions	952 lb. CO_2	952 lb. CO_2	**0 lb. CO_2**	0%

Heating electricity values include fan or pumping energy for homes that have forced-air or water-based heating systems powered by circulation pumps. The values for Hot Water include taps and faucets only; the energy consumed by the water heater to supply hot water for appliances such as clothes washers and dishwashers is included instead in the rows for those appliances.

HOME ENERGY SAVER™

YEARLY HEATING AND COOLING RESULTS

Show Details

	Total Cost
Cost	$669
Heating	$433
Cooling	$236

	Total Energy
Energy Use	374 therms 1,964 kWh
Heating	374 therms 413 kWh
Cooling	1,551 kWh

Notes: this house is 0% heated by wood fuel.
100% of the floor area is heated and 100% cooled.

Heating electricity values include fan or pumping energy for homes that have forced-air or water-based heating systems powered by circulation pumps.

What if my results don't match my energy bill?

HOME ENERGY SAVER™

YEARLY LARGE APPLIANCES AND WATER HEATING RESULTS

Show Details

Appliance	Total Cost
First Refrigerator	$85
Stove	$33
Oven	$11
Clothesdryer	$128
Clotheswasher	$28
Dishwasher	$29
Hot Water: Taps and Faucets	$171
Totals	$485

Equipment energy is the energy used by motors, heating elements, and burners inside your appliances. This number excludes the energy consumed by your water heater to supply hot water for appliances such as clothes washers and dishwashers (which is included instead in the rows for those appliances).

What if my results don't match my energy bill?

HOME ENERGY SAVER™

YEARLY SMALL APPLIANCES RESULTS

Show Details

Category	Energy Use	Energy Costs
Entertainment	345 kWh	$52
Home Office	361 kWh	$55
Miscellaneous Kitchen	464 kWh	$71
Other Appliances	120 kWh	$18

What if my results don't match my energy bill?

HOME ENERGY SAVER™

YEARLY LIGHTING RESULTS

Here is the calculated Yearly lighting bill based on the inputs you provided:

Show Details

Room	Energy Use	Energy Costs
All Bathrooms	202 kwh	$31
All Bedrooms	68 kwh	$10
Dining Room	120 kwh	$18
Family Room	77 kwh	$12
Garage	75 kwh	$11
Hall	114 kwh	$17
Kitchen	208 kwh	$32
Living Room	273 kwh	$41
Master Bedroom	68 kwh	$10
Outdoor Lighting	240 kwh	$36

What if my results don't match my energy bill?

HOME ENERGY SAVER™

UPGRADE RECOMMENDATIONS SUMMARY

Visit 'Recommendations' to see more information on each upgrade.

	Yearly Savings	Estimated Added Cost	How Much is Too Much?	Simple Payback Time	Estimated ROI	Avoided Emissions (lbs. CO_2)
Total for recommended upgrades	**$557**	**$12,280**	**$5,570**	**21**	**-1%**	**4,074**

Important Note: These are initial estimates only, and results may vary. If the owner has not already done so, we strongly recommend that they retain a professional energy auditor to develop a detailed work scope and budget for improving the home. We also recommend the Home Performance with ENERGY STAR program when considering home improvements.

Upgrades Requiring Investment

1. Thermostat
2. Clothes washer
3. Electric clothes dryer
4. Gas water heater
5. Cool roof
6. Duct Sealing
7. Attic insulation
8. Central air conditioner
9. Air sealing
10. Gas furnace
11. Windows
12. Dishwasher
13. Wall insulation
14. Duct Insulation
15. Slab insulation

Other benefits that often come along with these energy-saving upgrades

- Programmable thermostats can help keep your home more comfortable.
- ENERGY STAR® clothes washers can reduce water use significantly, leave the clothes drier thus reducing drying time and energy consumption, and reduce wear and tear on clothes.
- Natural gas clothes dryers reduce your home's peak load on the power grid compared to an electric dryer.
- Efficient gas-fired water heaters may hold their temperature longer following power interruptions and operate more safely.
- Cool reflective roofs reduce solar gains, keeping your home cooler and more comfortable. High temperatures are one of the factors that shorten the lifespan of roofing materials, so cool roofs may last longer than conventional roofs. Cool roofs also help lower the air temperature surrounding your house, which helps fight the urban heat island effect.
- Having a professional seal your home's air leaks can make your home more comfortable, reduce the risk of moisture damage, improve indoor air quality and fire safety, and help to prevent frozen water pipes.
- A well-insulated ceiling can make your home more comfortable and quieter, reduce the risk of moisture damage, enhance fire safety, make your home more disaster-resistant, and help guard against pipe freezing.
- ENERGY STAR® central air conditioners may operate more quietly, be more visually appealing, have better temperature and/or moisture control, and be easier to maintain than minimum efficiency air conditioners.
- Having a professional seal your home's air leaks can make your home more comfortable, reduce the risk of moisture damage, improve indoor air quality and fire safety, and help to prevent frozen water pipes.
- ENERGY STAR® gas-fired furnaces make your home more comfortable. Some models are less prone to causing indoor air quality problems or house fires.
- Energy-efficient windows can make your home more comfortable year-round, reduce condensation, block outside noise, improve fire safety, and cut back on ultraviolet radiation that can fade your carpets and furniture.
- Some ENERGY STAR dishwashers reduce water use and/or have shorter run times.
- Wall insulation can make your home more comfortable and quieter, reduce the risk of moisture damage, enhance fire safety, make your home more disaster-resistant, and help guard against pipe freezing.
- Well-insulated ducts can help avoid rooftop ice-dam formation during the winter
- A well-insulated slab foundation can make your home more comfortable, and guard against moisture problems.

HOME ENERGY SAVER™

UPGRADE RECOMMENDATIONS

What efficiency level would you like to model for the initial selection of upgrades? EnergyStar

What simple payback period would you like to use for selecting upgrades? 10

RECALCULATE

Rows that are dimmed are not included in the calculated values for the retrofit package. To include them check their boxes and recalculate.

Add/ Remove	Upgrade	Upgrade Choice & Description	Yearly Savings	Estimated Added Cost	How Much is Too Much?	Simple Payback Time	Estimated Return on Investment	Avoided Emissions (lbs. CO_2)
☐	Check/Uncheck All Upgrades	**Total for Selected Upgrades:**	**$557**	**$12,280**	**$5,570**	**21**	**-1%**	**4,074**
☒	Thermostat	ENERGY STAR-labele	$174	$ 85	$1,740	0	204%	1,990
☒	Clothes washer	MEF=1.42 WF=9.5 EN	$35	$ 90	$350	3	38%	115
☒	Electric clothes dryer	Switch to gas dryer	$63	$ 340	$630	5	16%	-46
☒	Gas water heater	EF=0.62	$31	$ 180	$310	6	15%	362
☒	Cool roof	Solar reflectance = 0.5	$27	$ 186	$270	7	14%	-17
☒	Duct Sealing	Reduce leakage to 6%	$90	$ 890	$900	10	6%	780
☒	Attic insulation	R-38	$153	$ 1665	$1,530	11	8%	1,279
☒	Central air conditioner	SEER=14 ENERGY S	$18	$ 218	$180	12	2%	77
☒	Air sealing	25% air leakage reduc	$68	$ 850	$680	13	7%	701
☒	Gas furnace	AFUE=90 ENERGY S	$61	$ 977	$610	16	1%	654
☒	Windows	2-pane/solar-control lo	$62	$ 1296	$620	21	3%	270
☒	Dishwasher	EF=0.58 ENERGY ST.	$11	$ 300	$110	27	NCE	68
☒	Wall insulation	R-11 wall cavity	$72	$ 2959	$720	41	NCE	653
☒	Duct Insulation	R-6	$19	$ 910	$190	48	NCE	169
☒	Slab insulation	R-5 slab edge	$9	$ 1334	$90	148	NCE	238
☐	Indoor lights	CFLs in high-use fixtur	$77	$ 88	$770	1	84%	618
☐	Refrigerator	15% better than standa	$11	$ 244	$110	22	2%	48

Important Note: These are initial estimates only, and results may vary. If the owner has not already done so, we strongly recommend that they retain a professional energy auditor to develop a detailed work scope and budget for improving the home. We also recommend the Home Performance with ENERGY STAR program when considering home improvements.

NCE = Not Cost Effective. This upgrade will not pay for itself in your situation. There may be other reasons, such as improved comfort, to implement the upgrade, or it could be made more cost-effective if the investment cost is reduced.

Note: Each of the upgrades in the table above are evaluated in isolation from the others. If the efficiency level is changed for one upgrade, its potential impact on other upgrades will not be counted in the row-by-row estimates. However, these kinds of interactions are included in the "package" totals associated with the whole-house totals and chart at the top of the page, for the upgrades selected as part of the package. For example, if the furnace efficiencies are raised, the energy savings from wall insulation will not change in the row estimate, but the incremental savings from including insulation in the package will be less due to the more efficient furnace's impact on reducing the energy required to make up heat losses through the wall (there is less energy being used, so less to save).

DETAILED UPGRADE RECOMMENDATIONS REPORT

This is a printable report of the upgrades selected for the home. These upgrades have the potential to save $557 each year on the utility bill.

Upgrade Package Summary:

Estimate Yearly Bill Savings:	**$557**
Estimated Lifetime Energy Savings:	**$11,140**
Estimated Added Cost:	**$12,280**
Maximum Price for 10 Year Payback:	**$257,880**
Return on Investment:	**-1%**
Upgrade Pays for Itself in:	**21 years**

You selected the following upgrades:

- Thermostat: Replace your thermostat with one that you can program.
- Clothes washer: Replace your washer. Pick a new one with an ENERGY STAR label.
- Clothes dryer: Replace your dryer. Switch from electric powered to natural gas
- Water heater: Replace your water heater. Pick an one that says energy efficient.
- Roof: Replace your roof with a "cool roof," madeof high solar reflectance materials. Be sure that the materials have an ENERGY STAR label.
- Air tightness: Have a professional seal your ducts to reduce leakage
- Attic: Add insulation in the attic floor. Try to get to R-38.
- Central Air: Replace your central air conditioner. Pick a new one with an ENERGY STAR label
- Air tightness: Have a professional seal the cracks and leaks in your home.
- Furnace: Replace your furnace, Pick a new one with an ENERGY STAR label.
- Windows: Replace your windows. Pick new ones with adouble-pane solar-control low-E argon gas panes and a wood frame.
- Dishwasher: Replace your dishwasher. Pick a new one with an ENERGY STAR label.
- Exterior Walls: Add insulation to the exterior walls. Try to get to at least R-11.
- Ducts: Add insulation around your ducts in unfinished spaces. Try to reach at least R-6.
- Slab Foundation: Insulate the outer edge of your slab foundation.

Note: The economic benefits for each of the upgrades below are evaluated in isolation from the other upgrades. If the efficiency level is changed for one upgrade, its potential impact on other upgrades will not be counted in the individual upgrade estimates. However, these kinds of interactions are included in the "package" totals associated with the whole-house totals and chart at the top of the page (above). For example, if the furnace efficiency is increased, the energy savings from wall insulation will not change in the table below, but the incremental savings from including insulation in the package will be less due to the more efficient furnace's impact on reducing the energy required to make up heat losses through the wall (there is less energy being used, so less to save).

Thermostat: Replace your thermostat with one that you can program.

Economic Benefits:

Estimate Yearly Bill Savings:	**$174**
Estimated Lifetime Energy Savings:	**$3,480**
Estimated Added Cost:	**$85**
Maximum Price for 10 Year Payback:	**$1,740**
Return on Investment:	**204%**
Upgrade Pays for Itself in:	**Under 1 year**

Additional Benefits:

Programmable thermostats can help keep your home more comfortable.

Upgrade Description:

Install an ENERGY STAR-labeled programmable thermostat, and program it to change the temperature settings when you are away from home and at night. EPA estimates that ENERGY STAR-labeled programmable thermostats can save consumers 10-15% on heating and cooling bills when used properly. Note: Our calculations bill savings and cost-effectiveness assume that the heating-season set-point is decreased 4 degrees F during the day 9 am to 5 pm and at night 11 am to 7 pm, while the cooling-season set-point is increased 3 degrees F during those same periods. Larger set-point adjustments can provide dditional bill savings.

Purchasing Tips:

- Some programmable thermostats have a "smart" feature designed to maximize energy savings. These thermostats continually monitor usage patterns in order to determine the best time to turn the system on in order to reach the desired temperature setting, while minimizing energy use.

More Information:

- ENERGY STAR thermostat product list
- General Information

[Return to upgrades list]

Clothes washer: Replace your washer. Pick a new one with an ENERGY STAR label.

Economic Benefits:

Estimate Yearly Bill Savings:	**$35**
Estimated Lifetime Energy Savings:	**$700**
Estimated Added Cost:	**$90**
Maximum Price for 10 Year Payback:	**$350**
Return on Investment:	**38%**
Upgrade Pays for Itself in:	**3 years**

Additional Benefits:
ENERGY STAR® clothes washers can reduce water use significantly, leave the clothes drier thus reducing drying time and energy consumption, and reduce wear and tear on clothes.

Upgrade Description:
When replacing your clothes washer, choose an ENERGY STAR-labeled model. ENERGY STAR clothes washers can reduce energy consumption by up to 70% and are available in top-loading and front-loading designs. Some ENERGY STAR models use up to 50% less water in addition to saving energy.

Note: Our calculations bill savings, typical upgrade costs, and cost-effectiveness are for a model with the lowest efficiency that qualifies for the ENERGY STAR label.

Purchasing Tips:

- Choose a clothes washer with high-speed spin cycles. This feature removes more water from clothes, which reduces the energy and time required for drying.
- Select a low water-use, high efficiency washer. Front-loading tumble-action washers can cut energy use by up to 70 percent, reduce water consumption significantly, and may actually get clothes cleaner. [1]
- Look for pre-soaking and/or "suds saver" options which conserve energy.
- Clothes washers come with EnergyGuide yellow and black labels. Use these labels to select the most efficient model for the capacity you have chosen.

More Information:

- ENERGY STAR clothes washer product list
- General Information from DOE
- Top-Rated Energy-Efficient Clothes Washers from ACEEE

[Return to upgrades list]

Clothes dryer: Replace your dryer. Switch from electric powered to natural gas

Economic Benefits:

Estimate Yearly Bill Savings:	**$63**
Estimated Lifetime Energy Savings:	**$1,260**
Estimated Added Cost:	**$340**
Maximum Price for 10 Year Payback:	**$630**
Return on Investment:	**16%**
Upgrade Pays for Itself in:	**5 years**

Additional Benefits:
Natural gas clothes dryers reduce your home's peak load on the power grid compared to an electric dryer.

Upgrade Description:

When replacing your electric clothes dryer, select a natural gas model. In many situations, this willreduce your overall energy bill because natural gas tends to cost less than electricity, for the same heating value.

Note: Our calculations bill savings, typical upgrade costs, and cost-effectiveness are for a minimum-efficiency natural gas dryer model. The defaultupgrade cost provided here assumes that a natural gas connection is available at your clothes dryer. If this is not the case, be sure to include the costof extending

Purchasing Tips:

- To use a gas dryer, your laundry room must have a gas hookup, with proper connections and safe venting of the gas's exhaust, in addition to an electrical outlet
- Look for a dryer with a moisture sensor, and use the dryness settings rather than timed drying.
- When replacing your clothes washer, choose a model with high-speed spin cycles. This feature removes more water from clothes, which reduces the energy and time required for drying.

More Information:

- General Information from DOE
- Laundry tips from ACEEE
- Information from the California Energy Commission

[Return to upgrades list]

Water heater: Replace your water heater. Pick an one that says energy efficient.

Economic Benefits:

Estimate Yearly Bill Savings:	**$31**
Estimated Lifetime Energy Savings:	**$620**
Estimated Added Cost:	**$180**
Maximum Price for 10 Year Payback:	**$310**
Return on Investment:	**15%**
Upgrade Pays for Itself in:	**6 years**

Additional Benefits:

Efficient gas-fired water heaters may hold their temperature longer following power interruptions and operate more safely.

Upgrade Description:

When replacing your gas water heater, choose an energy-efficient model with an Energy Factor of 0.62 or higher.

Note: Our calculations bill savings, typical upgrade costs, and cost-effectiveness assume the efficient water heater has an energy factor of 0.62 and recovery efficiency of 0.76. Higher efficiency units are available, and would provide additional energy savings.

Purchasing Tips:

- The most important measure of efficiency for water heaters is the Energy Factor EF. The higher the EF, the more efficient the water heater.
- Purchase a water heater whose tank is internally insulated with at least R-16. [5]
- A water heater that is too large for your home not only has a higher purchase cost but will increase your energy costs due to excessive cycling and standby losses. The resources below provide good, simple guidance on proper sizing of water heaters. The size, or "capacity", of a fuel-fired water heater should be judged by its first hour rating FHR, not its tank size. Due to larger burners, some gas water heaters with smaller tanks actually have higher capacities FHRs than models with larger tanks.
- Many types of water heaters are now available, such as "demand" tankless, "indirect" or "integrated", and solar-assisted water heaters. More Information
- New and/or efficient gas water heaters may have different venting and flue requirements. When replacing your water heater make sure your contractor assesses your existing flue, follows new code requirements for venting water heaters, and obtains necessary permits and inspections. [3]

More Information:

- General Information from DOE
- DOE Water Heating fact sheet
- Top-Rated Energy-EfficientWater Heaters from ACEEE
- GAMA consumer's directory click on "Consumers"
- How to prevent health and safety problems with combustion equipment

[Return to upgrades list]

Roof: Replace your roof with a "cool roof," madeof high solar reflectance materials. Be sure that the materials have

an ENERGY STAR label

Economic Benefits:

Estimate Yearly Bill Savings:	**$27**
Estimated Lifetime Energy Savings:	**$540**
Estimated Added Cost:	**$186**
Maximum Price for 10 Year Payback:	**$270**
Return on Investment:	**14%**
Upgrade Pays for Itself in:	**7 years**

Additional Benefits:
Cool reflective roofs reduce solar gains, keeping your home cooler and more comfortable. High temperatures are one of the factors that shorten the lifespan of roofing materials, so cool roofs may last longer than conventional roofs. Cool roofs also help lower the air temperature surrounding your house, which helps fight the urban heat island effect.

Upgrade Description:
When replacing your roof, choose a "cool" roofing material that qualifies for the ENERGY STAR label. These roofing materials reflect more of the sun's energy, staying cooler than typical materials and reducing your air conditioning bill. Our calculations bill savings, typical upgrade costs, and cost-effectiveness are for a low-slope roofing material with the minimum reflectance levels that qualify for the ENERGY STAR label 0.60 reflectance after some weathering. To qualify for the ENERGY STAR label, steep-slope roofs must have an initial solar reflectance of greater than 0.25.

Purchasing Tips:

- The ENERGY STAR criteria differ for low-slope less than 2:12 inches and high-slope roofs. The reflectance requirements are lower for high-slope roofs because in the past it has been difficult to make shingles and tiles highly reflective these materials are typically used for a high-slope roofs. High-reflectance products for high-slope roofs are now becoming more common in the market, so look for the highest reflectance materials you can for your roof type.

More Information:

- target="footnote"HRFF="http://www.energystar.gov/index.cfm?c=roof_prods.pr_roof_products">ENERGY STAR qualifying roofing product list
- Cool Roof Rating Council
- California Energy Commission
- Background about urban heat islands

[Return to upgrades list]

Air tightness: Have a professional seal your ducts to reduce leakage

Economic Benefits:

Estimate Yearly Bill Savings:	**$90**
Estimated Lifetime Energy Savings:	**$1,800**
Estimated Added Cost:	**$890**
Maximum Price for 10 Year Payback:	**$900**
Return on Investment:	**6%**
Upgrade Pays for Itself in:	**10 years**

Additional Benefits:
Having a professional seal your home's air leaks can make your home more comfortable, reduce the risk of moisture damage, improve indoor air quality and fire safety, and help to prevent frozen water pipes.

Upgrade Description:
Have a qualified professional seal your home's air leaks. Leaky houses waste energy because heated or cooled air can easily escape. Older homes tend to be leakier than newer homes. Tightening up a leaky house will reduce the heating and cooling bills. Recent advancements in air sealing technology allow specialists to go beyond the old techniques of caulking and weatherstripping around obvious places such as doors and windows. The biggest problems are usually hidden leaks in out of the way places such as attics, floors and walls, which are easily found and sealed by a specialist.Note: The annual bill savings and cost-effectiveness assume that your home's air leakage is reduced by 25%.

Purchasing Tips:

- To get the best results, hire a qualified contractor, preferably a "building performance contractor", or "energy auditor" to find out where the leaks are in your home's shell. Make sure the contractor uses a "blower door" test to find the air leaks. An infrared scan can be beneficial in addition to the blower door test. Check with your utility company; some offer no- or low-cost basic energy audits. However, the extra money you would spend to have the audit done by a home performance contractor is often well worth it. [5,6]
- Make sure your contractor tests the leakage rate after completing the sealing, not only to determine the degree of improvement, but also to ensure that the ventilation in your home is adequate. If you don't already have proper mechanical ventilation, consider

installing a ventilation system. Proper home ventilation will make your home healthier and more comfortable.

- Make sure your contractor performs a combustion safety test after sealing your home's air leaks. This test checks for backdrafting and carbon monoxide, and will help assure your home is safe. [9]
- If you choose to do the work yourself, follow the guidance in ENERGY STAR's Do-It-Yourself Guide to ENERGY STAR Homesealing.

More Information:

- ENERGY STAR air sealing including DIY guide to air sealing
- Common Air Leakage Sites in the Home
- Information about Air Leakage Testing
- Does your home have enough ventilation?

[Return to upgrades list]

Attic: Add insulation in the attic floor. Try to get to R-38.

Economic Benefits:

Estimate Yearly Bill Savings:	**$153**
Estimated Lifetime Energy Savings:	**$3,060**
Estimated Added Cost:	**$1,665**
Maximum Price for 10 Year Payback:	**$1,530**
Return on Investment:	**8%**
Upgrade Pays for Itself in:	**11 years**

Additional Benefits:

A well-insulated ceiling can make your home more comfortable and quieter, reduce the risk of moisture damage, enhance fire safety, make your home more disaster-resistant, and help guard against pipe freezing.

Upgrade Description:

Insulate your ceiling to at least R-38. In a typical home, half or more of the energy loss is through the exterior walls, floor and roof. Proper insulation, as well as sealing air leaks in your home's shell, is vital to reducing these energy losses.

Note: Our calculations bill savings, typical upgrade costs, and cost-effectiveness assume the ceiling insulation is increased to R-38. Insulating to a higher R-value would provide additional energy savings.

Purchasing Tips:

- Make sure all holes in the attic floor are sealed before you install insulation. Make sure there is a vapor retarder between the attic floor and the insulation to help prevent excess moisture from condensing on the insulation. However, if you are adding insulation on top of pre-existing insulation, don't install a vapor retarder, since it may trap moisture in the old insulation underneath. [5]
- If access to the attic is limited, blown-in cellulose or fiberglass insulation is your best bet. [5]
- Make sure the insulation does not block the attic vents, and that it is even and free of gaps. [5]
- When comparing contractors' bids, make sure they are for the same insulating value R-value, not just the same number of inches. [7]
- If you are doing the installation yourself, consider using cellulose. Cellulose insulation is less expensive and has a higher R-value per inch than fiberglass, and will not irritate your skin and lungs. [7]

More Information:

- General Information
- DOE Insulation Tips
- Installation Tips
- Tips for determining the R-value of old insulation

[Return to upgrades list]

Central Air: Replace your central air conditioner. Pick a new one with an ENERGY STAR label

Economic Benefits:

Estimate Yearly Bill Savings:	**$18**
Estimated Lifetime Energy Savings:	**$360**
Estimated Added Cost:	**$218**
Maximum Price for 10 Year Payback:	**$180**
Return on Investment:	**2%**

Upgrade Pays for Itself in:	**12 years**

Additional Benefits:
ENERGY STAR® central air conditioners may operate more quietly, be more visually appealing, have better temperature and/or moisture control, and be easier to maintain than minimum efficiency air conditioners.

Upgrade Description:
When replacing your central air conditioner, choose an ENERGY STAR-labeled model. These units can save 20% or more of your cooling bill.

Note: Our calculations bill savings, typical upgrade costs, and cost-effectiveness are for a model with the lowest efficiency that qualifies for the ENERGY STAR label 14 SEER. Higher efficiency models are available, which would provide additional bill savings.

Purchasing Tips:

- All new central air conditioners are labeled with a Seasonal Energy Efficiency Ratio SEER rating. Use the SEER to compare different models. The higher the SEER, the more efficient the unit.
- For maximum efficiency, ask your contractor to make sure the efficiency ratings for the indoor and outdoor coils match. Have the contractor install removable airtight access panels in the indoor unit so a service technician can clean the cooling coil easily.[4]
- Don't buy an oversized unit. A unit that's too big for your needs will waste energy, have less ability to control humidity, and have a shorter life due to excessive on-off cycling. Ask your contractor for an exact heat-gain calculation following ACCA Manual J procedures to determine the proper size unit for your house. Make sure the contractor sizes the unit based on the latent cooling load as well as the sensible cooling load. Do not rely on rule-of-thumb estimates as they tend to be inaccurate. If you've improved your home's efficiency since the last time you purchased an air conditioner, you may be able to purchase a smaller unit. [4,5]
- Consider buying a two-speed air conditioner, which can run very efficiently at its lower speedduring most of the cooling season, while using its higher speed to provide all the cooling you need on the hottest days.
- Locate the outside unit properly. Install it in a cool, shaded spot about two feet from the north or east side of your home. Avoid direct sunlight, which makes the unit work harder, and keep the unit away from other objects. Don't enclose the unit with a deck or shrubbery - it needs room to breathe.[4]
- If your duct system has leaks or disconnected portions, you will not reap the full energy savings you could get from a high efficiency air conditioner. Consider having your contractor check the entire length of your ductwork for leaks and seal any leaks with mastic-type sealant, not duct tape. It's now possible for a contractor to perform verified duct sealing by using a special fan to test duct system leakage before and after sealing. Also have the contractor check for and repair disconnected ducts - a common problem. Insulate any ducts in unheated spaces with R-6 or higher insulation.
- If you don't already have one, consider purchasing a programmable thermostat and having your contractor install it along with your new air conditioner.

More Information:

- ENERGY STAR central A/C product list
- Top-Rated Energy-Efficient Central A/C from ACEEE
- General Information from DOE
- Sizing Heating and Cooling Equipment

[Return to upgrades list]

Air tightness: Have a professional seal the cracks and leaks in your home.

Economic Benefits:

Estimate Yearly Bill Savings:	**$68**
Estimated Lifetime Energy Savings:	**$1,360**
Estimated Added Cost:	**$850**
Maximum Price for 10 Year Payback:	**$680**
Return on Investment:	**7%**
Upgrade Pays for Itself in:	**13 years**

Additional Benefits:
Having a professional seal your home's air leaks can make your home more comfortable, reduce the risk of moisture damage, improve indoor air quality and fire safety, and help to prevent frozen water pipes.

Upgrade Description:
Have a qualified professional seal your home's air leaks. Leaky houses waste energy because heated or cooled air can easily escape. Older homes tend to be leakier than newer homes. Tightening up a leaky house will reduce the heating and cooling bills.

Recent advancements in air sealing technology allow specialists to go beyond the old techniques of caulking and weatherstripping around obvious places such as doors and windows. The biggest problems are usually hidden leaks in out of the way places such as attics, floors and walls, which are easily found and sealed by a specialist.

Note: The annual bill savings and cost-effectiveness assume that your home's air leakage is reduced by 25%.

Purchasing Tips:

- To get the best results, hire a qualified contractor, preferably a "building performance contractor", or "energy auditor" to find out where

the leaks are in your home's shell. Make sure the contractor uses a "blower door" test to find the air leaks. An infrared scan can be beneficial in addition to the blower door test. Check with your utility company; some offer no- or low-cost basic energy audits. However, the extra money you would spend to have the audit done by a home performance contractor is often well worth it. [5,6]

- Make sure your contractor tests the leakage rate after completing the sealing, not only to determine the degree of improvement, but also to ensure that the ventilation in your home is adequate. If you don't already have proper mechanical ventilation, consider installing a ventilation system. Proper home ventilation will make your home healthier and more comfortable.
- Make sure your contractor performs a combustion safety test after sealing your home's air leaks. This test checks for backdrafting and carbon monoxide, and will help assure the safety of your home's occupants. [9]
- If you choose to do the work yourself, follow the guidance in ENERGY STAR's Do-It-Yourself Guide to ENERGY STAR Homesealing.

More Information:

- ENERGY STAR air sealing including DIY guide to air sealing
- Common Air Leakage Sites in the Home
- Information about Air Leakage Testing
- Does your home have enough ventilation?

[Return to upgrades list]

Furnace: Replace your furnace, Pick a new one with an ENERGY STAR label.

Economic Benefits:

Estimate Yearly Bill Savings:	**$61**
Estimated Lifetime Energy Savings:	**$1,220**
Estimated Added Cost:	**$977**
Maximum Price for 10 Year Payback:	**$610**
Return on Investment:	**1%**
Upgrade Pays for Itself in:	**16 years**

Additional Benefits:

ENERGY STAR® gas-fired furnaces make your home more comfortable. Some models are less prone to causing indoor air quality problems or house fires.

Upgrade Description:

When replacing your gas furnace, choose an ENERGY STAR-labeled model. These units can save 15% or more of your heating bill.

Note: Our calculations bill savings, typical upgrade costs, and cost-effectiveness are for a furnace with the lowest efficiency that qualifies for the ENERGY STAR label 90 AFUE. Higher efficiency models are available, which can provide additional bill savings.

Purchasing Tips:

- Buy the right size of furnace for your needs. If you have upgraded your home's insulation or windows since your last furnace was installed, you may be able to down-size your furnace i.e., buy a smaller-capacity furnace which can reduce the cost. If you buy a furnace that is too big for your home's needs, it will have short cycle times and reduced efficiency as a result. A furnace that is properly sized costs less to operate. Be sure to have your contractor perform a heat-loss, heat-gain calculation, and do not rely on rule-of-thumb sizing estimates, which are often inaccurate. [3]
- If you live in a large house, consider purchasing one of the higher efficiency furnaces that come with two-stage burners. These burners allow the furnace to operate at lower burn rates using less fuel when the home's heating demand is low. When the heating demand is higher, the second stage burner is employed. The additional savings from this feature may well be worth the cost if you live in a large home. [3]
- New and/or efficient furnaces often have different venting and flue requirements. When replacing your furnace make sure your contractor assesses your existing flue, follows new code requirements for venting furnaces, and obtains necessary permits and inspections. [3]
- All new furnaces are labeled with their Annual Fuel Utilization Efficiency AFUE. The higher the AFUE, the more efficient the unit.
- Consider selecting a furnace with an electronically commutated, or ECM, blower motor. ECM motors are considerably more efficient than standard motors. Consider this feature especially if you run your furnace fan all year long for such things as comfort or air cleaning. A furnace fan with an ECM motor could cut the cost of running the furnace fan by a factor of 5.[3]
- If your duct system has leaks or disconnected portions, you will not reap the full energy savings you could get from a high efficiency furnace. Consider having your heating contractor check the entire length of your ductwork for leaks and seal any leaks with mastic-type sealant, not duct tape. It's now possible for a contractor to perform verified duct sealing by using a special fan to test duct system leakage before and after sealing. Also have the contractor check for and repair disconnected ducts - a common problem. Insulate any ducts in unheated spaces to at least R-6.
- If you don't already have one, consider purchasing a programmable thermostat and having your contractor install it along with your new furnace.

More Information:

- ENERGY STAR furnace product list
- Consortium for Energy Efficiency furnace product list
- Top-Rated Energy-Efficient Furnaces from ACEEE

- General Information from DOE click on "Space Heating and Cooling"
- Sizing and Installation of Heating and Cooling Equipment
- How to prevent health and safety problems with combustion equipment

[Return to upgrades list]

Windows: Replace your windows. Pick new ones with adouble-pane solar-control low-E argon gas panes and a wood frame

Economic Benefits:

Estimate Yearly Bill Savings:	**$62**
Estimated Lifetime Energy Savings:	**$1,240**
Estimated Added Cost:	**$1,296**
Maximum Price for 10 Year Payback:	**$620**
Return on Investment:	**3%**
Upgrade Pays for Itself in:	**21 years**

Additional Benefits:

Energy-efficient windows can make your home more comfortable year-round, reduce condensation, block outside noise, improve fire safety, and cut back on ultraviolet radiation that can fade your carpets and furniture.

Upgrade Description:

When replacing windows, choose a double-pane, solar-control low-E, argon gas-filled, wood or vinyl frame window.

Note: The annual bill savings and cost-effectiveness assume that you replace all of your windows with windows that have U-factor=0.36 and SHGC=0.31 see the links in More Information for an explanation of these units. Bill savings will be less if you do not replace all of your windows, but the cost-effectiveness of replacing less than all of your windows should be approximately the same as shown above. Windows with even better performance are available, and could provide additional energy savings.

Purchasing Tips:

- Choose a window that is appropriate for your climate. ENERGY STAR window labels have a Climate Region Map that indicates which of four broad climate regions Northern, North/Central, South/Central, or Southern the window qualifies for. Make sure the window you choose is appropriate for the region you live in.
- Consider different types of glazing for windows on different sides of your house to benefit from passive solar energy and maximize energy benefits. Install the lowest U-value windows you can afford on north-facing windows. Select windows with appropriate low-e coatings for your location on the east, west, and south sides of your house. [6]
- To maximize energy performance, choose windows with larger unbroken glazing areas instead of multi-pane or true-divided-light windows. Applied grills that simulate true- divided-light windows, however, do not reduce energy efficiency. [6]
- Choose windows with good warranties against the loss of the air seal. If the glazing seal is lost, not only will fogging occur, but also any low-conductivity gas between the layers of glass will immediately be lost.[6]
- If summer heat gain is a problem in your house, look for windows with low-e coatings, especially spectrally selective low-e coatings, which significantly reduce solar heat gain and improve insulation without affecting visible light or color. Tinted windows also reduce solar heat gain, but they transmit less visible light.
- Look for the National Fenestration Rating Council NFRC label to help you compare performance and other features."
- Select windows with low air leakage ratings - between 0.01 and 0.06 cfm/ft. [6]

More Information:

- ENERGY STAR Windows
- Tips about efficient windows from DOE
- General Information from the Efficient Windows Collaborative
- ACEEE Consumer Guide to Windows
- California Energy Commission

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Dishwasher: Replace your dishwasher. Pick a new one with an ENERGY STAR label.

Economic Benefits:

Estimate Yearly Bill Savings:	**$11**
Estimated Lifetime Energy Savings:	**$220**
Estimated Added Cost:	**$300**
Maximum Price for 10 Year Payback:	**$110**
Return on Investment:	**-7%**

Upgrade Pays for Itself in:	**27 years**

Additional Benefits:
Some ENERGY STAR dishwashers reduce water use and/or have shorter run times.

Upgrade Description:
When replacing your dishwasher, choose an ENERGY STAR- labeled model. ENERGY STAR dishwashers must be at least 15% more efficient than federal efficiency standards. Models are available that are over twice as efficient as a standard new dishwasher. Many ENERGY STAR models reduce water consumption in addition to saving energy. Note: Our calculations bill savings, typical upgrade costs, and cost-effectiveness are for a model with the lowest efficiency that qualifies for the ENERGY STAR label.

Purchasing Tips:

- Choose a dishwasher that allows you the option of air drying rather than heat drying. Air drying uses much less energy than heat drying. [1]
- Look for models with internal "booster heaters" which permit lower water heater temperature settings.
- Choose a dishwasher that provides several wash cycle options, such as "energy-saving" or "short wash" cycles. These features reduce energy and water consumption.
- Select a dishwasher with the appropriate capacity for your needs. Dishwashers are classified as either compact or standard capacity. Compact models use less energy but also hold fewer dishes. If you have to run the compact dishwasher more often, you could actually use more energy than with a standard capacity dishwasher. [1]
- Dishwashers come with EnergyGuide yellow and black labels. Use these labels to select the most efficient model for the capacity you have chosen.

More Information:

- ENERGY STAR dishwasher product list
- Top-Rated Energy-Efficient Dishwashers from ACEEE
- Tips for Lowering Your Dishwasher Energy Usage from DOE

[Return to upgrades list]

Exterior Walls: Add insulation to the exterior walls. Try to get to at least R-11.

Economic Benefits:

Estimate Yearly Bill Savings:	**$72**
Estimated Lifetime Energy Savings:	**$1,440**
Estimated Added Cost:	**$2,959**
Maximum Price for 10 Year Payback:	**$720**
Return on Investment:	**0%**
Upgrade Pays for Itself in:	**41 years**

Additional Benefits:
Wall insulation can make your home more comfortable and quieter, reduce the risk of moisture damage, enhance fire safety, make your home more disaster-resistant, and help guard against pipe freezing.

Upgrade Description:
Insulate exterior walls to at least R-11. In a typical home, half or more of the energy loss is through the exterior walls, floor and roof. Proper insulation, as well as sealing air leaks in your home's shell, is vital to reducing these energy losses. Exterior walls can be the most important part of your shell to insulate, because of their large area.

Note: The annual bill savings and cost-effectiveness assume that you upgrade all of your exterior walls to R-11. The bill savings will be less if you do not upgrade the entire wall area, but the cost-effectiveness of upgrading less than all of your wall area should be approximately the same as shown above.

Purchasing Tips:

- You may be able to tell if your walls are insulated by removing an outlet cover on an exterior wall and looking into the wall cavity. Or, choose a closet or cabinet along an exterior wall. Drill two 1/4" holes into the wall about 4" apart, with one hole above the other; any insulation should be apparent. If you don't see any insulation inside the wall cavity, hire an insulation contractor to blow cellulose or fiberglass insulation into the exterior walls. Blown-in insulation does not require the walls to be torn open. [6]
- When comparing contractors' bids, make sure they are for the same insulating value R-value, not just the same number of inches. [7]
- Be sure to check the contractor's work. For blown-in insulation, make sure the contractors install the correct number of bags of insulation for your wall area, as listed on the bags. [7]

More Information:

- General Information
- DOE Insulation Tips
- Installation Tips
- Tips for determining the R-value of old insulation

[Return to upgrades list]

Ducts: Add insulation around your ducts in unfinished spaces. Try to reach at least R-6.

Economic Benefits:

Estimate Yearly Bill Savings:	**$19**
Estimated Lifetime Energy Savings:	**$380**
Estimated Added Cost:	**$910**
Maximum Price for 10 Year Payback:	**$190**
Return on Investment:	**-8%**
Upgrade Pays for Itself in:	**48 years**

Additional Benefits:
Well-insulated ducts can help avoid rooftop ice-dam formation during the winter

Upgrade Description:
Insulate all exposed ducts in unconditioned spaces to R-6, unless those ducts are already insulated to at least R-4.The average forced-air duct system loses about 30% of the energy produced by the furnace or air conditioner in the course of distributing air to the rooms. This energy loss can be reduced by sealing duct joints with mastic or high-quality duct tape, and insulating ducts in unconditioned spaces.Note: The annual bill savings and cost-effectiveness assume that you insulate your ducts to R-6.

Purchasing Tips:

When *replacing* your duct insulation, choose R-8 or follow your state or local code.

- Be sure a well-sealed vapor barrier exists on the outside of the insulation on cooling ducts to prevent moisture buildup. [8]
- Remember that insulating ducts in the basement will make the basement colder. If both the ducts and the basement walls are uninsulated, consider insulating both. [8]

More Information:

-
- General Information from DOE
- EPA's brochure "Should You Have the Air Ducts in Your Home Cleaned?"
- An Introduction to Residential [Duct] Systems

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Slab Foundation: Insulate the outer edge of your slab foundation.

Economic Benefits:

Estimate Yearly Bill Savings:	**$9**
Estimated Lifetime Energy Savings:	**$180**
Estimated Added Cost:	**$1,334**
Maximum Price for 10 Year Payback:	**$90**
Return on Investment:	**0%**
Upgrade Pays for Itself in:	**148 years**

Additional Benefits:
A well-insulated slab foundation can make your home more comfortable, and guard against moisture problems.

Upgrade Description:
Apply R-5 rigid foam insulation to the exterior edge of your slab foundation. In a typical home, half or more of the energy loss is through the exterior walls, floor and roof. Proper insulation, as well as sealing air leaks in your home's shell, is vital to reducing these energy losses.

Note: The annual bill savings and cost-effectiveness assume that you apply the R-5 foam insulation to the entire slab-edge area to a depth of two feet. The bill savings will be less if you do not upgrade the entire area, but the cost-effectiveness of upgrading less than all of the crawlspace wall area should be approximately the same as shown above. The default upgrade cost does not include the cost of excavatingthe foundation the excavation is assumed to occur for other reasons, such as installing drainage or landscaping.

Purchasing Tips:

- When comparing contractors' bids, make sure they are for the same insulating value R-value to the same foundation depth. [7]
- Address any exterior drainage problems as part of the insulation project. [5]

More Information:

- General Information
- DOE Insulation Tips
- Installation Tips
- Tips for determining the R-value of old insulation

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HOME ENERGY SAVER™

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Document 13

NATURAL GAS AND ELECTRICITY

NATURAL GAS IS YOUR BEST ENERGY VALUE

Remember when energy choices were easy? Electricity was used for lighting, electronics and motors. For heating, the obvious choice was natural gas. In today's changing energy market, technological innovations and fluctuating energy costs are causing some decision makers to rethink energy options.

To make decisions more complicated, varying billing structures and pricing options make it challenging to understand charges and effectively compare electricity costs to natural gas. The information that follows will help your business or organization sort through the options and make informed decisions. As you will read, historically natural gas has been an excellent energy value and, for most applications, continues to be a better choice than electricity.

The cost difference

Because electricity is billed in kilowatt hours (kWh) and natural gas in therms, it can be challenging to compare costs. Delivery and other charges make it even more difficult to accurately assess cost differences. The following table adjusts for the disparities, showing actual prices for natural gas and electricity for Minnesota commercial/industrial customers. As illustrated, even when a range of electric prices are considered, **natural gas prices are consistently two to three times lower than electric prices**.

In fact, when all charges are considered, for a $0.06 per kilowatt hour (kWh) electricity rate to be competitive, natural gas would have to cost $1.77 per therm. Historically and currently, natural gas costs are well below that price. Even the highest commercial/industrial natural gas firm rate on record is only $1.38 per therm. The higher cost was the result of 2005's unusually active and destructive hurricane season. See Table 1 below for an electric versus natural gas price comparison.

Another consideration is that electric utilities nationwide are projecting significantly increased costs as they update aging infrastructure to accommodate increased demand. Those costs will be passed along to the consumer and could even widen the gap between natural gas and electric costs.

Table 1

Click to view natural gas costs versus other fuels

Understanding your utility bill

Do you know how much your company or organization is paying for utilities? It's not enough to simply compare kilowatt and therm unit rates. As you can see in the actual bills below (see Tables 2 and 3), there are a variety of charges added to basic costs that can make a big difference to your bottom line.

What's your bottom line?
To find out how much you are paying for your utilities, take a closer look at your bills and, using the sample bills below (see Tables 2 and 3) as a guide, calculate your total cost per kWh and therm. Then take a second look at Table 1. How much less are you paying for natural gas than electricity?

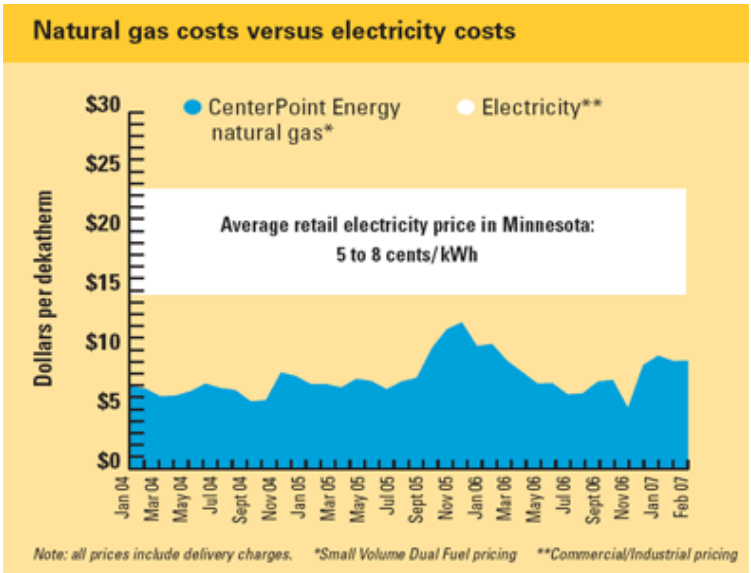
Table 2
Roll your mouse over the links below for more detailed information.

QUICK CLICKS

- Cost difference
- Understanding your bill
- Add efficiency to the equation
- Environmental impact

Download a full-color PDF fact sheet of Natural gas, your best energy choice.

Learn more about Natural gas prices.



Sample electricity bill

Charges and rates may vary by utility.

Type of charge	Qty	Unit rate	Total cost
1. Energy charge (kWh)	134,400	$0.039904	$5,363.10
2. Demand charge (kW)	273	$6.610000	$1,804.53
3. Interim rate adjustment			$506.66
4. Environment improvement (kWh)	134,400	$0.000610	$81.98
5. Environment improvement (kW)	273	$0.250110	$68.28
6. Fuel cost adjustment (kWh)	134,400	$0.000255	$34.25
7. Resource adjustment			$235.84
Sum of costs			**$8,094.64**

To determine how much you are paying per kWh:

Divide sum by total kWh	$8,094 ÷ 134,400
Total cost per kWh	**$0.0602**

Note: Taxes, city fees, basic service charges apply.

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Table 3
Roll your mouse over the links below for more detailed information.

Sample natural gas bill

Charges and rates may vary by utility.

Type of charge	Qty	Unit rate	Total cost
1. Delivery charge (therms)	1524	$0.11274	$171.82
2. Cost of gas (therms)	1524	$0.76393	$1,164.23

3. Interim rate adjustment	1524	$0.025255	$38.49

Sum of costs	**$1,458.86**

To determine how much you are paying per therm:

Divide sum by total therms	$1,458.86 ÷ 1,524
Total cost per therm	**$0.9573**

Note: Taxes, city fees, basic service charges apply.

To take it a step further, use the following equation to convert your actual kWh usage to therms:

1 kWh = 3,413 Btu = .0341 therms
Example: 134,000 kWh x .0341 = 4,587 therms

Add efficiency to the equation

Price of energy is one factor for determining fuel choice. But, it's also important to consider price in the context of efficiency. The example - (Table 4) below compares an electric and natural gas heating system. Even with the efficiency factor difference, the lower cost of natural gas makes it a much better choice. Use this table to help make comparisons in your facility.

Table 4

Space heating comparison

Commercial building with a 2 MM Btu heating load	**Electric equipment**	**Natural gas equipment**
Output – kWh : Btu*	586	2,000,000
Efficiency factor	.95	.80
Input – kWh : Btu	616.8	2,500,000
Annual operating hours	4,680	4,680
Load factor	0.35	0.35
Annual input – kWh : Therms	1,010,378	40,950
Unit energy cost – $/kWh : $/Therms	$.06	$.96
Annual energy cost	**$60,623**	**$39,312**
Annual savings with gas	**$21,311**	
Percent saved with gas	**35%**	
Incremental gas equipment cost	**$ 12,500**	
Payback	**.6 years**	

***1 Therm = 100,000 Btu = 29.3 kWh**

Natural gas is cleaner and greener

Environmental impact is another important consideration when choosing fuels. As you can see in (Table 5) below, the significant differences between natural gas and electricity make natural gas the better choice for the environment.

Table 5

Natural gas	Electricity
90% efficient – it takes far less energy to extract from its source and provide to user	27% efficient – largely due to the energy lost in electric generation
Lower greenhouse gas, sulfur dioxide, nitrogen oxide emissions and no mercury emissions	Higher greenhouse gas, sulfur dioxide, nitrogen oxide and mercury emissions
	duce source of many pollutants in Minnesota*

*Minnesota Pollution Control Agency, www.pca.state.mn.us, Sept. 8, 2006

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Natural gas – for yesterday, today and tomorrow
As shown in the examples provided, historical and current natural gas prices are significantly lower than the average retail electricity price. Natural gas remains the best value and best all-around energy choice. When you choose natural gas for your facility, you are making a wise decision for your bottom line and the environment.

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