Appendix 22E
Urban Water Quality Economics Modeling

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APPENDIX 22E
Urban Water Quality Economics Modeling

22E.1 Introduction

Urban water quality economic models are available for a portion of the South Coast and San Francisco Bay – South hydrologic regions. The first model, the Lower Colorado River Basin Water Quality Model (LCRBWQM), covers almost the entire urban coastal region of southern California. The second salinity model, Bay Area Water Quality Economic Model (BAWQM), covers the Bay Area from Contra Costa County south to Santa Clara County. The two water quality models only consider the economic costs of changes in salinity levels. Other water quality constituents are not included. The models use mathematical functions that define the relationship between salinity and physical damages incurred by water users to estimate water quality benefits.

22E.2 Lower Colorado River Basin Water Quality Model Description

22E.2.1 Description

LCRBWQM was developed by Reclamation (Lower Colorado Region) and Metropolitan Water District of Southern California (MWDSC) in 1998. This model was updated as part of MWDSC ’s and Reclamation’s 1999 Salinity Management Study. The current version of the model was updated with population data from the Department of Water Resources (DWR) and costs have been updated to 2007 levels. For a detailed description of LCRBWQM, see MWDSC and Reclamation (1999).

The model inputs from CALSIM II and DSM2 are SWP East and West Branch deliveries and TDS of these deliveries in mg/L, respectively. Some water diverted at Banks Pumping Plant (PP) is conveyed directly to southern California; other supplies are mixed in San Luis with water diverted at Jones PP. A routine to estimate salinity of urban water supplies delivered to the South Coast based on timing of urban deliveries, mixing in San Luis Reservoir, and salinity estimates at Edmonston PP is used to obtain improved salinity inputs for LCRBWQM.

LCRBWQM divides MWDSC ’s service area into 15 sub areas. The division of the south coast region into sub areas provides detail regarding sources of water and salts in each area. This detail is necessary because each region obtains very different shares of supply from different sources, and some sources, the Colorado River and groundwater, in particular, have higher salinity than others. Table 22E-1 shows the sub areas and recent estimates of population in each.

The model is designed to assess the average annual salinity benefits or costs based on demographic data, water deliveries, TDS concentration, and cost functions that define the relationship between TDS and costs in a number of categories. Cost information was developed based on technical studies, consumer surveys, interviews of contractors and experts, and engineering judgment. All of the cost data (such as the price of water heaters, water rates, reverse osmosis costs, etc.) were obtained from retail stores, warehouses, available reports and publications, and engineering cost estimates. For a complete reference of the data and their source material see MWDSC and Reclamation’s Salinity Management Study (1999).

Table 22E-1
South Coast Regions In LCRBWQM and Population Estimates for 2009, 2025, and 2060
Urban Water Quality Economics Modeling

Region	County	2009	2025	2060
North West	Ventura	626,260	705,700	937,753
San Fernando Valley – West	Los Angles	2,527,593	2,827,015	3,208,923
San Fernando Valley – East	Los Angles	1,475,549	1,569,041	1,781,007
San Gabriel Valley	Los Angles	3,279,010	3,388,677	3,846,462
Central Los Angeles -	Los Angles	1,505,986	1,731,736	1,965,681
Central and West Basins	Los Angles	596,752	668,191	758,459
Coastal Plain	Los Angles	301,710	340,240	386,204
North West Orange County	Orange	189,658	212,271	233,032
South East Orange County	Orange	3,059,182	3,282,229	3,603,234
Western MWD	Riverside	818,858	1,176,182	1,707,561
Eastern MWD	Riverside	660,662	862,918	1,252,770
Upper Chino	San Bernardino	471,273	502,046	643,662
Lower Chino	San Bernardino	360,667	546,454	700,597
North San Diego	San Diego	301,747	410,019	511,707
South San Diego	San Diego	2,782,253	3,144,781	3,924,706
Total		**18,957,160**	**21,367,500**	**25,461,757**

Table 22E-2 shows average salinity levels and water sources for a recent baseline 2025 condition.

Table 22E-2
Average LCRBWQM Salinity and Water Supply Shares for a Recent 2025 Condition
Urban Water Quality Economics Modeling

Region	Avg Salinity (mg/l)	Average Percent of Regional Supply from Each Source						
		Groundwater Recovery	Groundwater	Surface Water	LA Aqueduct	SWP East	Co. River Aqueduct	SWP West
North West	319	0%	11%	0%	0%	88%	0%	0%
San Fernando V. W	275	0%	14%	0%	54%	32%	0%	0%
San Fernando V. E	444	23%	19%	0%	0%	37%	21%	0%
San Gabriel Valley	352	1%	57%	6%	0%	0%	13%	23%
Central Los Angeles	318	0%	12%	0%	24%	49%	8%	7%
Central & W Basins	427	2%	36%	0%	0%	40%	22%	0%

Region	Avg Salinity (mg/l)	Average Percent of Regional Supply from Each Source						
		Groundwater Recovery	Groundwater	Surface Water	LA Aqueduct	SWP East	Co. River Aqueduct	SWP West
Coastal Plain	528	23%	21%	0%	0%	36%	20%	0%
NW Orange County	423	1%	42%	0%	0%	0%	21%	37%
SE Orange County	432	11%	12%	0%	0%	0%	28%	50%
Western MWD	333	2%	39%	0%	0%	0%	9%	50%
Eastern MWD	525	2%	27%	4%	0%	0%	52%	15%
Upper Chino	223	1%	24%	5%	0%	0%	0%	70%
Lower Chino	464	21%	62%	0%	0%	0%	3%	14%
North San Diego	553	1%	3%	4%	0%	0%	67%	24%
South San Diego	538	2%	6%	12%	0%	0%	59%	22%

The cost categories are shown in Table 22E-3. Salinity costs can be classified generally as those incurred privately, and those incurred by utilities. Private cost categories are residential, irrigation, commercial, and industrial. Utility costs include recycled water costs, water utility costs, and groundwater recharge costs. The types of salinity benefits (reduced costs) in each category are shown in Table 22E-3.

Table 22E-3
Categories of Costs Counted by LCRBWQM
Urban Water Quality Economics Modeling

Private	Utility
Residential	**Recycled Water and Wastewater Costs**
• Life of Water Pipes	• RO Cost for Replenishment
• Life of Water Heaters	• RO Cost for Indirect Recharge
• Life of Faucets	**Commercial / Industrial**
• Life of Garbage Grinders	• RO Cost for NPDES
• Life of Clothes Washers	• RO Cost for Impacts of Water Softeners on POTWs
• Life of Dish Washers	**Water Utility**
• Houses using Bottled Water	• Production
• Houses with Water Softeners	• Distribution
• Cost of Cleaning Products ($)	**Salt Removal in Groundwater Recharge**

Private	Utility
Irrigation – by Crop Type	• Direct Recharge
Commercial	• Indirect Recharge
• Sanitary, cooling, irrigation, kitchen, laundry, misc.	
Industrial	
• Process Water – Softening, minor, demineralization	
• Cooling Towers	
• Boiler Feed	
• Sanitation & Irrigation	

- Residential: Residential benefits from reduced salinity levels include an increase in appliance and residential plumbing life along with a reduction in use of bottled water and water softener products. Equations estimate expected life as a function of salinity; see Table 22E-4 for representative equations. Residential benefits account for the costs of appliance and water softener products.
- Agricultural: Benefits from reduced salinity levels are increased crop yield (Ayers and Westcot, 1985). The total damages incurred by agriculture are a function of crop area, total yield, and the reduction in yield from salinity levels.
- Commercial and Industrial: Benefits from reduced salinity levels include decreased costs for water softening and treatment, water for cooling, and extended equipment life. Costs are estimated using a dollar per mg/l per unit of water used. Economic damages are also a function of water use, cost of treatment and maintenance.
- Water Utility: Utility benefits from reduced salinity levels include an increased life of treatment and distribution facilities. The total economic damages from salinity are a function of population and useful life of facilities.
- Groundwater Recharge: Groundwater benefits from reduced salinity levels result from a reduction in salt removal costs. Therefore, the total economic damages from salinity levels in groundwater are a function of total water pumped.
- Recycled Water: Recycled water benefits from reduced salinity levels are leeching costs and salt removal costs. Total economic damages from salinity include additional salinity added by increased use of water softeners.

Table 22E-4
Equations for 1983 Household Costs and Life of Household Features as a Function of TDS or Total Hardness
Urban Water Quality Economics Modeling

Customer Cost Category	Measure (Dependent Variable)	Equation Constant	Parameter on TDS (mg/l)	Parameter on Total Hardness (mg/l $CaCO_3$)
Bottled water usage	% households that use bottled water	5.7	+0.04	
Soap and detergent use	1982 $/household/yr	85		0.12
Water softeners	1983 $/household/yr	-4.7		0.11

Customer Cost Category	Measure (Dependent Variable)	Equation Constant	Parameter on TDS (mg/l)	Parameter on Total Hardness (mg/l $CaCO_3$)
Water softeners	% households that use softeners	-7.13		0.094
Water heaters	Life yrs	13.1	-0.00415	
Galvanized waste water pipe	Log Life yrs	1.549	-0.000797	
Galvanized water pipe	Life yrs	16.56	-0.0067	
Brass faucets	Log Life yrs	1.304	-.0007	
Dishwashers	Log Life yrs	1.03	-0.00034	
Clothes washers*	Life yrs	14.42	-0.011+ .0000046TDS	
Garbage disposals*	Life yrs	9.2	-0.004 + .000001TDS	
Faucets and fixtures	Life yrs	11.5	-0.003	

*The parameter includes TDS because the equation is a quadratic, i.e. $Yrs = a + bTDS + cTDS^2$

The model can calculate the incremental economic benefits or costs of SWP and Colorado River Aqueduct salinity changes compared to a selected baseline condition. It also estimates the change in economic damages from a change in the volume of imported supply. Increasing deliveries of SWP supplies reduces overall economic damages in the model, because SWP deliveries are blended with the much more saline supplies such as the Colorado River. The model can be run with a 2009, 2025, or 2060 level of development for population, water use, agricultural cropping patterns, and water supply.

22E.3 Bay Area Water Quality Model

22E.3.1 Description

The salinity economics Bay Area Water Quality Model (BAWQM) includes the portion of the Bay Area region from Contra Costa County south to Santa Clara County. The model was developed and used for the economic evaluation of a proposed expansion of Los Vaqueros Reservoir (Reclamation, 2006).

Separate calculations are provided for Contra Costa Water District and another region consisting of Alameda County Water District, Zone 7 (Zone 7), and Santa Clara Valley Water District (SCVWD). The model inputs include water supply (provided by CALSIM II) and chloride concentrations in mg/L from DSM2. For CCWD, water quality estimates are based on diversion volume and water quality at Old River and Rock Slough. For the other areas, water quality is based on diversion volume and salinity at Banks PP. In the districts receiving SWP water, water quality is a function of other supplies as well as SWP imported supplies. Data on the quality of other supplies estimated for Alameda County Water District and Santa Clara Valley Water District (Reclamation, 2006).

This model counts residential benefits only. Input data on the percent of households having appliances and the initial cost of appliances are required. Data on the salinity of supplies obtained through CCWDs intakes, through the South Bay aqueduct, and through the San Felipe system must be developed for alternatives. The model also required the average salinity of any other, non-project supplies. Table 22E-4 shows damage equations used in the model.

The model also requires data on the number of affected households, the percent of households having appliances, and the initial average cost of affected appliances. The number of households in the affected service areas is expected to increase over time. Data is included for Alameda County Water District, Contra Costa Water District (CCWD), Zone 7, and SCVWD (Reclamation, 2006). Numbers of households in the intermediate years is estimated by interpolation.

Input data on the percent of households having appliances and the initial cost of appliances are provided in Table 22E-5. Data from the Statistical Abstract of the United States (1999 and 1987) suggests that the percent of houses in western states having dishwashers is increasing over time, but the share of households with clothes washers is not. Data for the other types of fixtures and appliances are from other sources (Reclamation, 2006).

Unit costs from Reclamation (2006) were updated. Prices are indexed to a common point in time using several series: an appliance price index provided by the U.S. Department of Commerce, International Trade Administration (2009), price indices for plumbing fixtures and water heaters provided by the Bureau of Labor Statistics (Economagic.com, 2009), and the west urban consumer price index for household furnishings and operations, also form the Bureau of Labor Statistics (Economagic.com, 2009). Data on share of households using appliances is from the CCWD 1998 Residential Water Survey Evaluation (Whitcomb, 2000).

The model uses estimated relationships between salinity and damages to residential appliances and fixtures to estimate the benefits from changes in salinity. Specific model outputs compare change in average salinity and change in annual salinity costs.

Table 22E-5
Other Data Required For Bay Area Water Quality Model
Urban Water Quality Economics Modeling

Customer Cost Category	Percent of Households with this Practice or Appliance		Cost in 2000 Dollars	Notes
Bottled water usage	Depends on salinity		$277 per household using bottled water	
Appliances or Fixtures	**2000**	**2020**	**Initial Cost, $/Unit**	
Water heaters	100	100	$398	
Galvanized waste water Pipe	25	25	$1,729	Initial cost not provided by Sonnen, $1000 in ‘83 $ assumed
Galvanized water pipe	25	25	$1,902	
Brass faucets	100	100	$147	5 per households in 1983 $
Dishwashers	60	70	$707	Increase suggested by USDC data
Clothes washers	70	70	$668	
Garbage disposals	50	50	$132	
Faucets and fixtures	100	100	$483	

22E.4 Limitations

The two urban water quality models do not consider economic benefits associated with water quality constituents other than salinity. Consumers may be willing to pay to avoid many other water quality constituents. These constituents include many man-made chemicals, pathogens and byproducts that may have health implications. Consumers should be willing to pay to reduce the chance, frequency and severity of adverse health effects, but these benefits are not counted by the municipal water quality benefits approach used here. Some consumers may be willing to pay for drinking water that has less taste and odor even if they do not buy bottled water. Also, water and wastewater utilities have costs associated with many water quality constituents other than salinity.

Both models use dated information about the current ownership patterns and costs of modern water using appliances. The BAWQM does not include commercial, industrial or public users and costs to utility infrastructure are not included. The model should be reviewed to determine if, with Los Vaqueros reservoir, marginal salinity costs are likely to occur within the range of salinity experienced.

Both models currently obtain an expected value by use of an average quality of water supplies over the hydrologic period. This simplification could result in error in economic benefits estimates. More detail in the quality of supplies used over the hydrologic period might result in a different expected value and could also provide insights about water management in dry periods.

As of 2008, regions not represented in LCRBWQM or BAWQM include the San Joaquin River, Central Coast, Tulare Lake, and South Lahontan regions. Water quality economics must be evaluated based on an extrapolation from results from the two models. The ratio of water supply benefits between the San Francisco Bay – South and the South Bay and the “other urban areas” is multiplied by the water quality benefits in the South Coast. A factor of .4 was used to reduce benefits to account for the perceived lack of blending benefits in the “other urban areas.” This approach was very limited in detail.

22E.5 References

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