

# Thinking about pricing urban water

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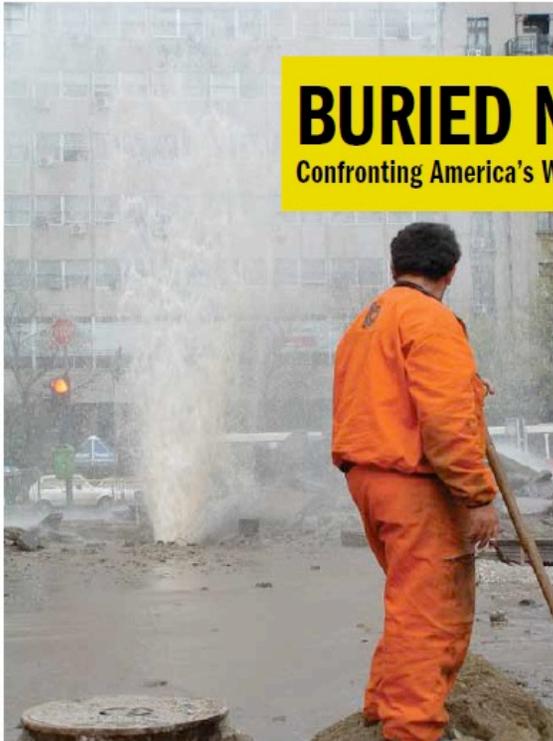
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# Sources of concern about rate design

- Need to finance upgrades of the water system
  - Investment backlog
    - Aging infrastructure
    - Failure of tariffs to cover depreciation on capital stock
  - Protecting against climate change
- Concerns about efficient pricing of water – pricing in scarcity
  - “The efficient water price is the long run marginal cost of supply.”

# BURIED NO LONGER:

Confronting America's Water Infrastructure Challenge



## Trillion dollar investment backlog

Figure 6: Aggregate Needs for Investment in Water Mains Through 2035 and 2050, by Region

2011-2035 Totals			
(2010 \$M)	Replacement	Growth	Total
Northeast	\$92,218	\$16,525	\$108,744
Midwest	\$146,997	\$25,222	\$172,219
South	\$204,357	\$302,782	\$507,139
West	\$82,866	\$153,756	\$236,622
<b>Total</b>	<b>\$526,438</b>	<b>\$498,285</b>	<b>\$1,024,724</b>

2011-2050 Totals			
(2010 \$M)	Replacement	Growth	Total
Northeast	\$155,101	\$23,200	\$178,301
Midwest	\$242,487	\$36,755	\$279,242
South	\$394,219	\$492,493	\$886,712
West	\$159,476	\$249,794	\$409,270
<b>Total</b>	<b>\$951,283</b>	<b>\$802,242</b>	<b>\$1,753,525</b>



American Water Works Association

The Authoritative Resource on Safe Water®

# Historically, how did we finance water supply infrastructure?

- Answer: through property taxes.
- Municipalization of urban water in the US occurred 1870-1930 hand-in-hand with rise of local property taxes.
- Even poor homeowners were willing to pay for their residential water supply because of the direct benefit:
  - Improved fire control with water pipes water in the street
  - Health benefits from piped water and sewer
  - Reflected, in turn, in increased property values
    - A virtuous circle
- This financing pathway is no longer as effective
  - Property tax no longer major part of water revenue stream
  - Property values don't reflect decaying pipes

# Pricing water at long-run marginal cost is generally not politically feasible

- Most municipal supply systems have a mix of sources, with varying different costs. There is thus a rising step-function of supply costs.
  - For example, local surface/groundwater, \$100/AF; water from conservation programs, \$300/AF; water from a regional wholesaler \$650/AF; reclaimed wastewater \$850/AF.
- In that case, the long-run marginal cost is significantly higher than the *average cost*.
- Pricing every drop of water sold at long-run marginal cost would raise excessive revenue.
  - Raising excess revenue and then mailing rebate checks is politically clunky.

## The question

- The question becomes: *which units* of water should be priced at long-run marginal cost?
- It becomes a question of rate structure.
- There needs to be a strategic choice of which units to price at long-run marginal cost while ensuring that, overall, the rate structure is fairly close to average cost so as to not raise excess revenue.

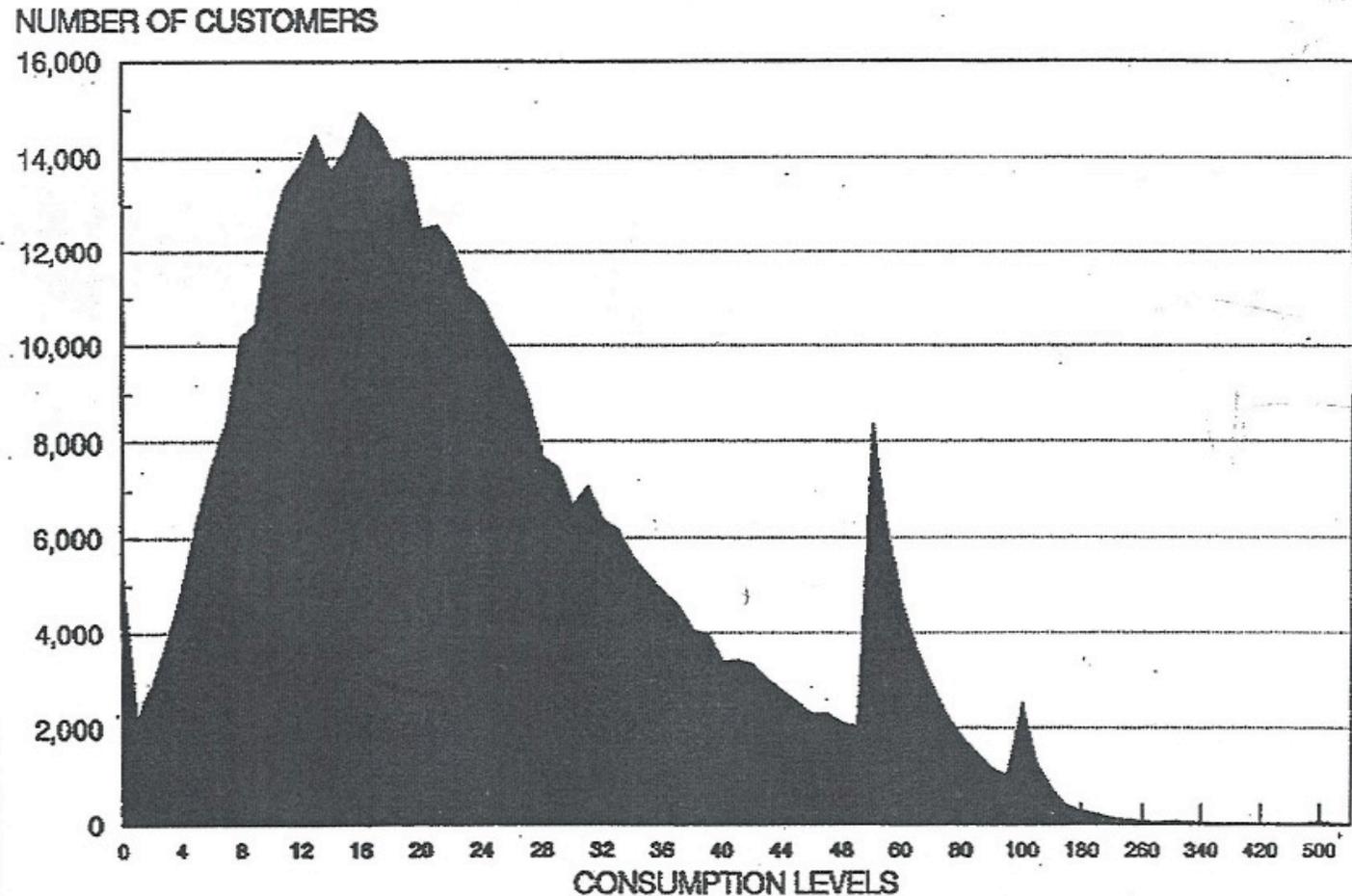
What is the goal rate making? A choice

A. Raising revenue

B. Shifting behavior

- These goals are mutually opposed
  - If demand is price responsive, pricing can accomplish B – but not A
  - If demand is unresponsive to price, pricing accomplishes A, not B.
- Part of the rate structure is attentive to A, part to B.

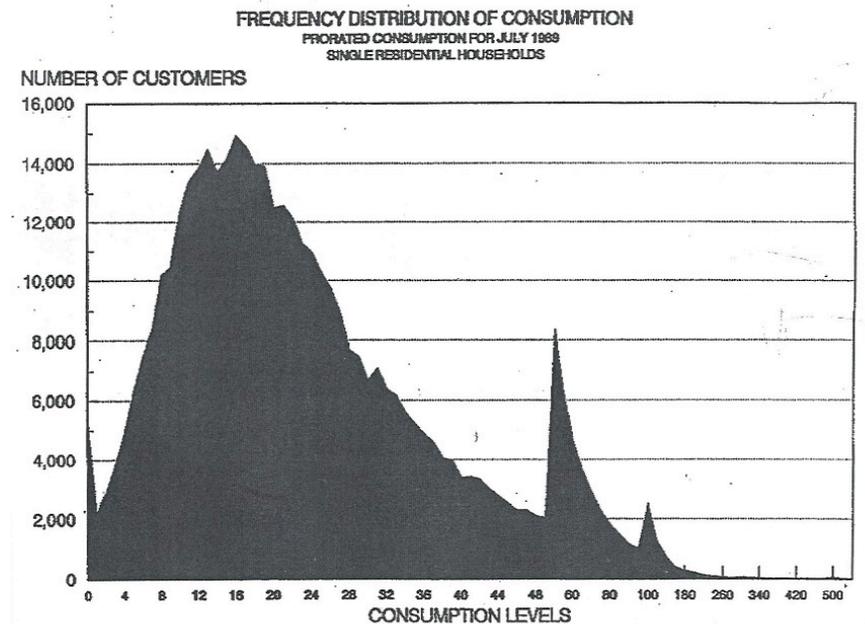
FREQUENCY DISTRIBUTION OF CONSUMPTION  
PRORATED CONSUMPTION FOR JULY 1989  
SINGLE RESIDENTIAL HOUSEHOLDS



- Great heterogeneity in individual demand.
- Probably driven as much by *idiosyncratic* factors as by
  - Income
  - Household size
  - Climate
- That breakdown of factors is rarely measured

Given the long-tail in household demand, what is the policy goal?

- To shift the entire distribution to the left?
- To pull in the right tail?
- I think it is often the latter



There is a widespread feeling that water is a merit good – something that must be accessible by all

- The right to water is an embodiment of this.
- The result is that raising the price of water purely to send a signal to water users, when the increase is not cost-justified, is generally not feasible.
  - It is ruled out for regulated investor-owned water utilities.
  - For municipal utilities, the politics work against this.
  - California's Prop 218 outlaws this for municipal water utilities.
- Rate reform is best coupled with advocacy regarding financing needed new investment.
  - Similarly, it is desirable that the components of the rate structure be cost-justified.

# The price responsiveness of residential water use

- I have no doubt that some pockets of residential water use are price-responsive.
  - The response is clearly larger in the long-run than the short-run
- Clearly, in a drought or some other crisis, residential users will respond by cutting their water use.
  - But, this may be mainly a response to the crisis, not a price response per se.
- There are two key factors that dampen the price responsiveness
  - Most people have absolutely *no idea* of how much water they are using, whether in total or for particular end uses.
  - Residential water use is highly influenced by physical features of the home – built-in water using fixtures & appliances, lot size, landscaping. Also family size.
    - Changing water use is much more difficult than substituting LED for an incandescent bulb.

- The result is that, for most homes, if they use 500 gallons per month, this is almost certainly NOT because they chose to use 500 gallons, as opposed to 480 gallons or 520 gallons.
  - But, this is what we assume when we impute a household demand function.
- In most cases, most of the time, no conscious choice actually occurs.

# What, then, is the behavioral response?

- Taking shorter showers, washing dishes less, etc
  - Obviously works in the short run (e.g. in a drought)
  - Will this persist in the long run?
- Letting the lawn die?
  - Obviously works in the short run (e.g. in a drought); probably not in the long run.
- Changing appliances, changing landscaping
  - Occurs, if at all, in the long run?
  - Occurs when move into a new home?
  - Occurs if there is a vigorous program – either regulating landscaping or offering a generous subsidy to change?

- Instead of a conventional demand function, it may be more productive to think in terms of a *change in demand function*.

- For example, Zhao et al.
 
$$w_{ijt} - w_{ijt-1} = \alpha(p_{jt} - p_{jt-1}) + \sum_{c=1}^C \gamma_c A_c (Temp_t - Temp_{t-1}) + \sum_{c=1}^C \delta_c A_c (Prec_t - Prec_{t-1}) + (\epsilon_{ijt} - \epsilon_{ijt-1})$$

- Another idea, also implemented by Zhao et al, is to estimate demand conditional on features of house.

- This is a form of short-run demand

Zhao et al.	
Full sample	-0.36 (-5.67)
With pool	-0.37 (-4.30)
Without pool	-0.32 (-3.46)
With grass	-0.35 (-5.09)
Without grass	-0.47 (-3.63)
Mesic subdivision	-0.23 (-1.07)
Xeric subdivision	-0.33 (-4.27)

- A third idea is to estimate a frontier demand function, or a frontier demand-change function.
  - Divergence from the frontier could be purely random or it could also be a function of covariates.
- The underlying idea is to partition the variation in individual water use into idiosyncratic versus specific deterministic factors.

- While the distinction between short- and long-run response to price is an important one, most of the literature does not attempt to model this explicitly, using either an appropriately designed statistical model or an appropriately designed data set.
  - For example, a partial adjustment model (Boland & Carver, 1980)
    - Short run elasticity = -0.05; long run = -0.7.
    - Speed of adjustment factor = 0.07. It would take ~19 years for demand to achieve 95% of the long-run adjustment to a price increase ultimately reducing demand by 20% reduction in demand.
  - Or long differences (decade to decade) versus short-differences (year-to-year)

# Price vs quantity as regulatory tools

- Economists are used to thinking of price as the pre-eminent regulatory tool.
- In a famous article, economist Weitzman (1974) explored the policy trade-off between using price vs quantity regulation.
  - He postulated two alternative objectives for regulatory policy:
    - Certainty about achieving a particular quantity outcome (e.g., quantity of water used).
    - Economic efficiency: achieving whatever reduction in quantity occurs at minimum economic cost.
  - He showed that the choice of instrument depends on which policy objective is the more important.
    - If certainty about quantitative outcome is the more important, quantity regulation is better.
    - Arguably, this is sometimes the case for water managers.
  - A different factor is the relative salience and power of a price signal vs a quantity goal.
    - Quantity limit may be a more potent tool.
    - It provides a clearer signal about the specific behavioral change needed.

# To induce a shift in a person's behavior

- The person has to be paying attention
  - It has to be salient
  - Typically, this means a price differential that is (i) quite large, and (ii) well marked
- The person has to see clearly what he could be doing differently
  - The change has to be realistic and feasible
- It has seem reasonable or worthwhile to the person to do something differently
  - It would save some money
  - It is the right thing to do – it serves a worthwhile purpose

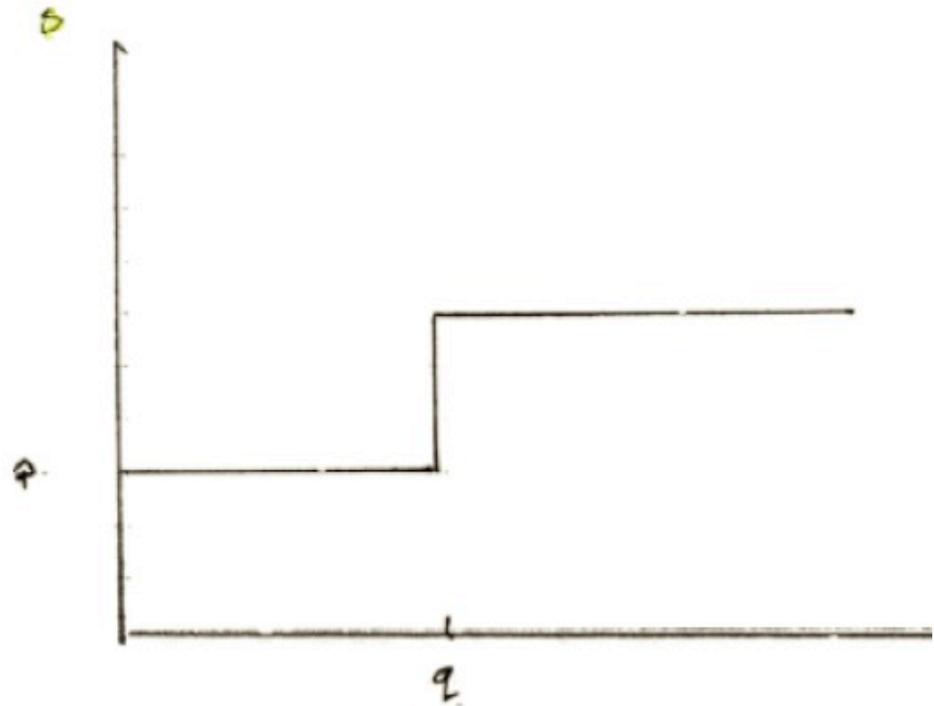
**To be successful, a rate structure has to achieve this.**

# The LADWP rate structure 1993-2015.

- Design goals
  - a. Offer water users flexibility
  - b. Provide an incentive tailored in some manner to individual users situation.
  - c. Carry normative weight
- The key innovation, which arose by chance, was to have a two-block structure with a switch point that varied across users and was tailored to achieving (b) and (c).

# Two-tier structure

- The upper block is set equal to an estimate of the long-run marginal cost (the cost of new supplies).
  - This bloc is meant to provide flexibility for users.
  - It is not intended to raise much revenue.
- The lower block is set a bit below average cost.
- The structure was designed to be revenue neutral annually for most customers.



# The criteria for choosing the individualized switch points

- The switch points vary by temperature (3 climate zones) and lot size (5 categories). A separate switch point for each.
- The location of the switch points was determined by:
  - 125% of median use across all users in that cell
  - An estimate (by me) of reasonable indoor and outdoor use in that cell.
    - A bit like a best practice analysis.

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*Monthly Billing Units Billed at Low Initial  
Block Rate*

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<i>Lot Size (square feet)</i>	<i>Temperature Zone</i>	<i>Winter</i>	<i>Summer</i>
less than 7,500	Cool	13	16
	Moderate	14	18
	Hot	14	19
7,500–10,999	Cool	16	23
	Moderate	17	26
	Hot	17	27
11,000–17,499	Cool	24	36
	Moderate	25	40
	Hot	25	42
17,500–43,559	Cool	28	45
	Moderate	29	51
	Hot	29	53
> 1 Acre	Cool	36	55
	Moderate	38	62
	Hot	38	65

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This rate structure endured for 22 years, until a new LADWP Board came in and decided to complicate it.

- It was politically robust.
- There is some empirical evidence that it was effective in bringing down the right-tail of the distribution.
- What it lacked was a messaging strategy: for budgetary reasons, LADWP was unwilling at the time to include a message in utility bills pointing out how close you were to getting a lower price and how much you would have to reduce your use to accomplish this.

# My hypotheses

- The switch point can be a salient signal to water users.
- The closer water use is to a switch point (from above?) the greater the responsiveness to the price (price differential).
- There is some econometric evidence showing this.
  - While there is evidence that users response more to average water price than marginal water price, there is also evidence that users close to a switch point respond quite strongly to the marginal price (Nataraj & Hanemann, 2010).

## What about individualized switch-points (budget-based water rates)?

- These certainly have had some impact in reducing demand (Baerenklau, Schwabe and Dinar, 2013).
- Depending on how the individualized switch points are chosen, this may or may not differ much from my LAWP rate structure.
- They may lack some of the appearance of best practices and fairness if they excessively respect idiosyncratic variation in levels of baseline water use.
- They share the basic objective: creating a visible, salient price signal that is tailored in some manner to the users' circumstances because (i) this is fair, and (ii) it is more likely to be an incentive that influences behavior.