

The Influence of Individual Metering on Water Consumption in Multi-family Dwellings

By

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B.S., Managerial Economics, 1987
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Submitted to the Department of Urban Studies and Planning in Partial Fulfillment of the
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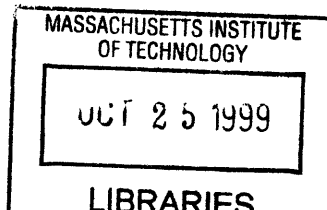
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ABSTRACT

The Commonwealth of Massachusetts does not allow residential landlords to bill tenants for water consumption. Data on water consumption patterns of owner occupants and renters was gathered from three Massachusetts towns and cities: Brookline, Cambridge, and Boston. Multiple regression analysis was performed on the data. Renters who are not billed for water consumption were found to use a statistically significant greater amount of water than their owner occupant counterparts who pay for their own consumption.

Analyses of similar studies in other states are also contained. A legal review and summary provides information on the legal framework that allows landlords in other states to pass on water costs to the tenants. Current legal impediments to implementation of water submetering in Massachusetts as well as proposed legislation are discussed. The author recommends the adoption of water submetering policy by the Commonwealth of Massachusetts as a way to promote conservation of natural resources and as a way to make individuals equitably responsible for their water consumption. The author believes such policy will aid in reducing overall water consumption as well as wastewater creation and the need to process it.

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Outline

- I. Hypothesis
 - A. People will consume more of a natural resource when they are not billed for use
- II. History of Measurement and Billing
 - A. Water usage and measurement from roman times
 - B. Modern day water meters
 - C. Water Submetering Methods
 - D. Introduction of Electricity and Gas into buildings in Massachusetts
 - i. Master metering
 - ii. Submetering individual apartments
- III. Data Analysis and Conclusions from Similar Studies in other States
 - A. Seattle Water Study
 - B. Denver Water Study
 - C. New York Water Study
 - D. NAA Water Study
- IV. Presentation of Data and Analysis
 - A. Analysis of Boston Water Data
 - B. Analysis of Brookline Water Data
 - C. Analysis of Cambridge Water Data
 - D. Analysis of Combined Data
- V. Legal Review
 - A. Federal Perspective
 - B. Status in other States
 - C. Status in MA – prohibiting legislation
 - D. Leg. In other states
 - E. Leg. In Massachusetts enabling legislation
- VI. Recommendations and Conclusions
 - A. Conclusions from Data Analysis
 - B. Support and Opposition to Submetering in Massachusetts
- VII. Bibliography
- VIII. Acknowledgements

The Influence of Individual Metering on Water Consumption in Multi-family Dwellings

I. Hypothesis

It is my hypothesis that people will consume greater quantities of a natural resource when they are not charged for their consumption. Specifically, it had come to my attention that apartment dwellers in Massachusetts are presently not charged for their water consumption. In an age where annual water and sewer rate increases are outpacing inflation and towns are seeking alternative water supplies in order to keep up with the current housing boom, it seems inconceivable that tenants are allowed to consume unlimited quantities of water without any incentive to conserve.

Some recent studies have been conducted in different parts of the country to determine whether or not billing tenants for consumption affects their usage, however, to my knowledge there have not been any such studies conducted in Massachusetts. In order to make a determination whether or not there is over consumption due to the current lack of accountability for usage by renters, it was necessary to obtain data from several cities and towns in the state.

II. History of Measurement and Billing

A. Water Usage and Measurement from Roman Times

Water metering has occurred for thousands of years, as our ancestors realized the value of this limited natural resource. Oases Gadames, North Africa is claim to a water meter which has been in operation for over 3,000 years. This “meter” essentially consists of a pot on a string with a small hole in it. The pot is lowered into the community spring and each farmer is allowed an equal number of pots of water, as determined by the tribal water commission. This water then

flows through a series of irrigation ditches, as controlled by a series of gates, to the appropriate farmer's field. "The British were astonished after having conquered the Indians, to find a power catchment of 80,000,000 cubic meter capacity; dam length, 20 kilometers; dam height, 6 meters; which compare favorably with the dams of today. These arrangements were made without today's technical knowledge."¹

Until approximately 313 B.C., the Romans took their water directly from the Tiber River, wells, and springs. As the population of the city grew, so did its water needs. Thus a series of 9 aqueducts were constructed over the next three hundred years. A detailed description of an ancient Roman water commissioner, Frontinus, can be found in a book titled *De Aquis Urbis Romae* (translated in an English book by Clemens Herschel titled *The Water Supply of the City of Rome*). Frontinus explores the idea of measuring consumption for public and private purposes. He further describes a system of measuring water volume through the use of *adjutages*. *Adjutages* were pipes of various sizes and diameters. In their early attempts to measure water consumption, the ancient Romans assumed that the diameters of each pipe would determine the amount of total flow. Frontinus began to realize that the *adjutages* did not take into account the velocity of the water flowing through the pipe due to their angles or relative elevations in relation to the water supply. An *adjutage* pointing slightly upwards would certainly have less velocity and therefore less volume than one pointing downwards. These *adjutages* were used to connect users to the system and bore the official stamp of Rome indicating that their size had been officially approved for water distribution. Cheaters were thought to have connected larger diameter pipes in an effort to circumvent the system.

¹ Water Meters- Selection, Installation, Testing, and Maintenance, AWWA Manual M6, Ed Seruga, 1986, p. 2.

“In 1730, Henri Pitot, a distinguished French engineer, in experiments on the River Seine, used a vertical glass tube with the short, 90 degree tip at the lower end pointing upstream to determine whether there was a relationship between the rise of water in the tube and the velocity of flow... his discovery that the height to which the water rose in his tube was proportional to the square of the stream velocity came in the same year that John Bernoulli published the fundamental relationship of head to velocity squared of water flowing through pipes.”²

Early American settlers would obtain their water through wells, streams, and lakes. In fact, many thought water was not a healthy form of drink. “In 1652, Boston incorporated the country's first waterworks, formed to provide water for fire fighting and domestic use. As fire was a common hazard in those days of wood-framed houses and stores, and chimney fires always a risk, it was imperative that a ready supply be on hand.”³ Water was carried short distances in limited service areas through a network of gravity fed wooden pipes. When a fireman needed to access water they would cut a hole in the wooden pipe and attach their hoses to the opening. For the people who received water via this wooden pipe system, water would have a woody taste due to its pooling in certain sections of pipe. “Before 1795, Bostonians relied on local wells, rain barrels and a spring on the Boston Common for their water. In 1795, private water suppliers developed a delivery system, using wooden pipes made from tree trunks, to deliver water from Jamaica Pond to the City of Boston. In the 1840s, the City of Boston (pop. 50,000) was faced with water quality and capacity problems. Jamaica Pond was lacking in capacity and becoming increasingly polluted causing several epidemics. There were several disastrous fires that could not be

² Water Meters- Selection, Installation, Testing, and Maintenance, AWWA Manual M6, Ed Seruga, 1986, p.5.

contained due to lack of delivery capacity.”⁴ Boston achieved higher pressure and delivery capacity in 1848 through the introduction of aqueducts connecting Lake Cochituate and the Brookline Reservoir as well as the introduction of iron pipes.

Sewage was disposed in the streets, fields, and in the same streams and rivers that were being used for drinking water. “It would be more than midway through the 19th century before young America would develop reasonably efficient water and sewage systems, and for the great invention of the water closet to make an appearance.”⁵

It wasn’t until 1829 that the Tremont Hotel in Boston became the first hotel in America to receive indoor plumbing. “Many thought bathing was a health hazard.. [in 1845].., Boston forbade bathing except on specific medical advice.”⁶ Around 1845, the development of sanitary sewers contributed to the development of the toilet and indoor plumbing. Homes were beginning to connect to the public water supplies. Prior to 1845, filling the bathtub involved going outdoors to a pump and filling the tub with individual buckets of water. By “1845, the installation of sanitary sewers began to pay off with an outlet for waste water, indoor plumbing and working water closets were getting closer to fruition. Unfortunately, bad plumbing and the stench from open sewer connections made some new homes uninhabitable.”⁷ By the early 1860s, bathrooms were becoming common place in new construction. By the turn of the century, bathrooms were becoming large and luxurious. This trend of large bathrooms reversed itself after both of the World Wars when there was a need for more efficient apartment style

³ History of Plumbing in America, Plumbing and Mechanical, July 1987, <http://www.theplumber.com/usa.html>.

⁴ Early Boston Water System, MWRA, <http://www.mwra.state.ma.us/water/html/hist2.htm>

⁵ History of Plumbing in America, Plumbing and Mechanical, July 1987, <http://www.theplumber.com/usa.html>.

living. The first room to receive a reduction in size was the bathroom. As we see today, this trend has once again changed in favor of the large luxurious bathroom.

The importance of fresh clean water was realized shortly after the Civil War when “the germ theory of disease was proven true, that contagion could be traced to contaminated water supply and unsanitary waste disposal. With waves of cholera, typhus and typhoid fever sweeping the country, the people turned to the resources of government to investigate the causes. The English Pubic Health Code of 1848 became a model plumbing code for the world to follow. The plumber, long vilified in early years, saw his status upgraded to that of the Sanitarians. The idea of sanitary plumbing systems within buildings was an American development that soon spread throughout Europe. Over the next two decades and more, plumbing health codes expanded coverage to encompass examination, and licensing.”⁸

B. Modern Day Water Meters

Currently there are three types of meters which are most widely used in the United States to measure residential and commercial water consumption; the turbine meter (also known as turbos), the positive displacement meter, and the compound meter.

Turbine Meters

Reinhard Woltman developed the prototype to the modern turbine meter around 1790 in Hamburg, Germany. The meter was essentially a lightweight waterwheel, which originally measured surface velocity of rivers and streams. The wheel was attached to a register by a gear train. Accuracy could be adjusted by calibrating the register in relation to the cross section of the river. “About 1790, Woltman modified the wheel so it could be used beneath the surface”⁹ (ie: in a closed pipe). Early English meters were designed by Siemens and Adams and were put into

⁶ History of Plumbing in America, Plumbing and Mechanical, July 1987, <http://www.theplumber.com/usa.html>.

⁷ History of Plumbing in America, Plumbing and Mechanical, July 1987, <http://www.theplumber.com/usa.html>.

⁸ History of Plumbing in America, Plumbing and Mechanical, July 1987, <http://www.theplumber.com/usa.html>.

⁹ Water Meters- Selection, Installation, Testing, and Maintenance, AWWA Manual M6, Ed Seruga, 1986, p. 7.

service in 1865. The main problem with these Siemens meters was corrosion due to the use of iron and bronze. “It is difficult to ascertain just when the first of the modern turbine meters was built. One leading US manufacturer shipped its first unit, called a Torrent meter, in 1896. Its design was later refined to be similar to present construction.”¹⁰ The modern turbine meter works essentially the same as Woltman’s original metering device. A propeller or turbine spins as water passes from the supply line, through the propeller, and then on through the building’s internal plumbing. As the propeller turns, the number of rotations is calculated either by a gearing system, which links the propeller to the register or by a magnetic system where a sensor counts the number of times the magnet spins past it. Thus each revolution of the propeller represents a small volume of water passing from the street into the local plumbing. Adjustment of these meters is done by physically comparing the volume of water actually passing through the pipe against the meter reading. This is also known as a calibration test. If the meter reading does not match the actual water volume, the gearing can be adjusted appropriately. In the case of the magnetically activated register, a percentage of magnetic impulses can be dropped out electronically until it approximates the actual flow within acceptable tolerances. After 1978, class II turbines were developed which are made of newer materials, which have longer life and better accuracy over a range of time and flow speeds.

Displacement Meters

“The most popular types of displacement meters originated as modifications of pumps that were run backwards. Instead of using the mechanism as a prime mover, the water under pressure moved the piston or pistons. The number of strokes or the measured volume per cycle was

¹⁰ Water Meters- Selection, Installation, Testing, and Maintenance, AWWA Manual M6, Ed Seruga, 1986, p. 7.

converted into gallons or cubic feet by appropriate gearing.”¹¹ There is some debate as to who invented the first American water meter, but it was believed to be around 1850 by Henry Worthington of New York. The meter was not highly accurate because it measured the number of piston strokes and did not take into account that the length of the strokes would vary due to compression of the rubber piston cushions caused by rapid water flows. An English clergyman invented another version of the displacement meter around the same time, it was known as the nutating disc. The disc type meter essentially wobbles or nutates based upon the flow of water across the disc. The number of rotations is linked to the register either directly through gearing or magnetically.

Compound Meters

Compound meters were developed to improve the accuracy of measurement of water over a wide series of flows, primarily in the case of a large commercial building. The meter typically combines a large turbine meter, ideal for measuring large flows, with a small displacement meter, which is ideal for measuring lower flows. These two meters are connected by a compounding valve, which automatically directs the water, by the appropriate meter based on the flow rate. The importance of quick changeover of this valve is critical to proper functioning of the unit. Without quick changeover, some measurement of volume will be lost.

Acceptance of Meters by Utilities

The practice of charging for water by metering its use was questioned by water utilities for quite some time. One of the chief objections was that occupants of metered homes would try so hard to keep water charges at a minimum that they would not use enough water for sanitary purposes. It was even reported that some users placed a tub under a faucet and allowed water to drip into the tub at a rate

¹¹ Water Meters- Selection, Installation, Testing, and Maintenance, AWWA Manual M6, Ed Seruga, 1986, p. 12.

too slow for the meter to register. Water was dipped from the tub with a pail as needed.

Establishing a monthly minimum charge, for which enough water was furnished to provide for reasonable sanitary needs, solved this problem. No carryover of unused allowance to the next month was permitted. This method opened the way to universal metering, once good meters were available, and it was found that the total cost of operating a metered system was less than the cost without meters since waste was reduced.¹²

C. Water Submetering Methods

There are two general methods of water billing being used in apartment buildings today in parts of the country where owners can legally charge tenants for consumption. The first method is to install a meter on the water line servicing the tenant's apartment. This is called submetering. Unfortunately, in many older buildings the plumbing prohibits the easy installation of a single meter. Systems are now becoming available which will allow the monitoring of actual hot and cold water use at each individual point of consumption within the apartment. Individual meters are attached to each of the hot and cold lines feeding every sink, tub, and toilet, and a single radio transmitter, which tabulates the results, gathers signals from these devices. Consequently leak detection should be very easy because the landlord will have the ability to match the total volume of water consumed by the apartment complex with the sum of each of the individual apartments consumption. If the totals do not match, individual apartment usage can be examined to determine if there is a leaky faucet or toilet. If additional data is needed, submeters can then be installed for various sections of the building in order to determine if there is a leaking pipe somewhere between the main meter and the submeters located in each apartment.

¹² Water Meters- Selection, Installation, Testing, and Maintenance, AWWA Manual M6, Ed Seruga, 1986, p. 21.

The other system in use today for water cost allocation is RUBS or Ratio Utility Billing System. Typically this system is employed in buildings where submetering is impossible or cost prohibitive. Each apartment is billed for consumption based on a variety of formulas depending on the laws in that particular state. Some owners subdivide the main water bill by each apartment in proportion to the percentage of square feet that each apartment represents. In some cases where the tenant is paying for hot water use, the property owner attaches a submeter to the tenant's hot water feed. Based on the amount of hot water consumed relative to other tenants in the building, the landlord allocates the cost of the main water bill to each tenant. All of these RUBS methods rely on some form of proportional versus exact billing for use. It is interesting to note that at the same time as some states prohibit the landlord from billing proportionately, these states allow their municipal sewer treatment to be billed proportionately. In most states, residential sewer bills are not billed based on actual sewage outflows, but rather they are billed as a proportion of the inflow of water to the residence. This formula method for sewage billing would seem to be arbitrary relative to RUBS. Short of installing a sewage outflow meter, the municipality makes the assumption that all of the water consumed in your household flows back into the waste treatment process. In cases where consumers are using their household water to fill a swimming pool or water their yard, they are in fact subsidizing other residents' sewage costs as they are being billed for sewage outflow that doesn't exist. Some municipalities now allow for residents to get a separate irrigation meter to avoid such inequities.

D. Introduction of Electricity and Gas into Buildings in Massachusetts

As recently as 1906, electricity was just being introduced to residential and commercial customers. An excerpt from Edison Light magazine illustrates both the novelty of having electricity in buildings as well as Edison's marketing at the time:

It may be stated that there is no house, whether it be the most modest or the most palatial, in which the Electric Light cannot be used to the advantage of the occupants and to the great increase of their comfort, health and happiness. No residential structure, then, should be planned or erected without provision for electric wiring as preliminary to the introduction of the electric light. Especially should no apartment house be erected without this due and early provision. The best tenants, sooner or later, will demand an illuminant, which will add to their conveniences and comfort- increase their safety and further their well being. Owners, also, will find immediate rewards in employment of the electric light in halls, stairways and other places used in common, because of its convenience, safety and economy. Wiring, to be sure, can be installed after the completion of a building with less trouble and expense than might be expected; but it will be less troublesome and less expensive if done while the building is under way.¹³

It is hard to imagine that it was less than a hundred years ago that electricity was being introduced into buildings. At the time of its introduction, it was primarily being used as a “safe” alternative to gas and oil. Early Edison literature indicates that prior to the wide introduction of meters, which appears to have taken place between 1910-1920, people were billed monthly based on the number of light bulbs that they owned. Edison computed electricity usage by multiplying the number of bulbs in the residence by the amount of consumption, which Edison had calculated per bulb. As meters came into use, billing could be done based on actual consumption. . As early as the invention of electricity itself, Edison realized the importance of developing and using meters. In addition to helping to measure overall system capacity meters were seen as a most important source for accurate and continual revenue generation. “He [Edison] foresaw that one of the essential parts of such a [electrical distribution] system would be a meter that was accurate, cheap and durable...”¹⁴

¹³ In Apartment Houses, Edison Light, October 1906, p. 6.

¹⁴ Development of Electricity Meters, Charles H. Ingalls, Edison Life, July 1920, p. 229.

What is interesting to note is that the introduction of electricity into apartment buildings was viewed as a luxury not a necessity. Electricity, unlike water, was viewed as something which had a cost associated with its use and production. Consequently, water was introduced to a multi unit building via one main feed and one meter. Electricity was introduced at first on an individual apartment basis and consequently had separate meters from its introduction.

A January 1917 edition of Edison Life magazine describes how Edison enticed potential electric customers in apartment buildings through their trial meter program. Provided that the apartment was wired, fixtures installed, and connected to Edison's lines, "a meter and Mazda lamps [were] installed without obligation on the part of the prospective customer, either to pay for the current or to continue to use electricity, unless the prospect [found] by experience that he wants to."¹⁵ Salespeople quickly learned that the best way to cultivate electric usage throughout an apartment building was to give a free trial to an on premise janitor or building manager. The janitor would then ask all new tenants if they wanted electric service.

"If the tenant says "yes", his name is given the Edison salesman and he calls for the application. If the tenant says "no," he is handed one of the trial meter postals. In this way, the salesman usually gets the name of the new tenant and sees him on the day of moving in, or before if possible. How valuable this cooperation is with men who are in close touch with and have the confidence of the tenants is self evident."¹⁶

Gas had been used for lighting since 1822. According to Mike Conors of Boston Gas, "every town (in the Boston area) used to have a gassing plant and distribution company. Gas was produced through a process of distilling coal or oil, the resulting product being called manufactured gas. Gas was transported via a series of wooden pipes primarily to serve as street

¹⁵ Trial Meters at Apartments, A. H. Heining, Edison Life, volume 8, January 1917, p. 3.

lighting.” Natural gas only came to the area as recently as the 1950s when the interstate pipeline, which carries natural gas up from the Gulf Coast oil fields, reached New England. Before the pipeline came to New England in the 1950’s, oil was the primary fuel for heating.

III. Data Analysis and Conclusions from Similar Studies in other States

In order to examine the effect of direct billing for water consumption in Massachusetts, one needs to first look at available studies across the country concerning this type of data. Some studies were conducted which examined the effects of metering for consumption where there was previously no metering taking place. Other studies tried to control external variables by installing metering systems on several test residences while comparing the results against other similar residences which did not pay for consumption. The vast majority of such studies indicate that billing for consumption has a net reduction on gross consumption. There are, however, no such studies to my knowledge that were conducted in the Boston area.

Before one examines the findings of any of the studies, one must first understand the components of residential water consumption. Residential consumption typically consists of two main components: indoor and outdoor usage. Outdoor usage is primarily for watering of lawns and gardens as well as washing vehicles. It is this component of residential usage which appears to be most price elastic. When prices of water go up (or a billing program to the consumer is implemented where one did not exist before) the first thing that the consumer reduces is outdoor consumption. Indoor consumption on the other hand appears to be more price inelastic. As prices increase, the consumer may become more aware of taking shorter showers, however basic needs such as using the lavatory or washing dishes do not change drastically.

¹⁶ Trial Meters at Apartments, A. H. Heininger, Edison Life, volume 8, January 1917, p. 5.

Certainly, over the years as water prices have increased, more and more consumers have installed flow limitation devices such as 2 gallon per minute showerheads. Government, realizing the value of water as a limited natural resource has also tried to mandate limitations on water use such as the requirement that all new toilets purchased in the United States are only 1.6 gallons per flush compared with their 7-gallon predecessors.¹⁷ Where then is the ability of consumers to reduce their indoor water consumption? This ability would seem to focus on the continued use of flow limitation devices, conscious efforts to limit shower and laundry times as well as the ability to detect leaks more rapidly. According to Wade Smith of Water Management Services, Inc., it is estimated that approximately 20% of the toilets in America leak over 20,000 gallons of water per year. This estimate is not hard to believe when one understands that the water industry estimates that a faulty toilet clapper can waste as much as 200 gallons per hour. We all can recall at some point hearing the toilet continuously hissing or trickling. If the annoying trickling sound does not encourage the resident to call a plumber, then certainly the worry of an excessive water bill will. However, in many cases one cannot hear or see a toilet leak. When they also do not receive a bill for consumption they may not be aware that in fact there is a leak in the individual home or apartment. It is this leakage component which seems particularly significant in most studies.

A. Seattle Water Study

Al Dietemann, senior program analyst at the Seattle Public Utilities, recently conducted a study comparing water usage between tenants who were billed for consumption and tenants who were not billed for consumption. The first submetering project, which was conducted in Seattle, was

an installation of submeters in a nine unit apartment building. Five adjacent buildings with similar tenant mix and histories were used as a control group. “Once tenants started getting bills and paying for their consumption, their use dropped dramatically. The results from one building were very encouraging, with an average savings of 27% in water and sewer use... with a simple payback [for submeter installation costs] of under four years to the building owner.”¹⁸ Inspired by these results, Seattle conducted an additional study in 1996 with nine buildings, which represented a variety of tenants, demographics, and building types. Since most new apartment buildings in the Seattle area are being built with submeters, the properties retrofitted for the second study were primarily older apartment buildings.

For the second study, April 1996 through February 1997 usage was examined.

“Seven [buildings] showed some savings, but in two buildings water use increased. Average water savings for the 103 apartment units in the nine study buildings was 7.7%....Reasons for variations in pilot project water savings include changes in pre and post occupancy rates in the buildings, demographic changes among tenant turnover, building and fixture age, and of course price signal motivated tenant behavior changes and leak repairs.”¹⁹

Mr. Dietemann suggests that a more controlled study, which would control for such variables, is needed. What is interesting is his mention of the term “price signaling”. It would seem that certain income levels may be more price sensitive to being billed for water usage and therefore may be able to more effectively control their non-essential water consumption. It is also suggested that submetering on an existing building be implemented at the time of tenant turnover. Existing tenants may object to submetering during the middle of their lease. Laws in

¹⁷ Detroit Free Press Website, July 27, 1999, <http://www.freep.com/realestate/renews/qdulley16.htm>

¹⁸ Sub-Metering: The next Big Conservation Fronteir?, Conserve '99, AWWA February 1999.

¹⁹ Sub-Metering: The next Big Conservation Fronteir?, Conserve '99, AWWA February 1999.

different areas may also prohibit such billing during the current lease period especially if the tenants were under the assumption that water was included with the price that they were currently paying.

These studies raise some non-data issues. Specifically, some tenants raised concerns that they wanted to see the utility involved in the billing and metering. The installation, monitoring, and billing of these submeters was conducted by a private for-profit corporation. Tenants also thought that there should be some sort of reduction in rent in exchange for their paying for water consumption. Installation of submeters at the beginning (or end) of the lease would seem to circumvent the need for rebates in that tenants would be aware that they would be paying for their water consumption at the outset. As for the monitoring, installation, and billing by a private third party, this issue would seem to warrant further exploration. In talking with numerous water departments, none appear interested in taking on this responsibility. The Boston Water Department made it politely clear to me that they currently monitor and service 87,000 accounts and that they were not looking to have to service 587,000 accounts due to submetering. There may be a need to establish regulations for these third party companies, to insure the accurate measurement and billing of individual consumption. Building owners, however, have their concerns that regulations affecting the submetering companies will cause building officials to discover other pre-existing plumbing conditions in their buildings which may have to be brought up to code. If the installation of submeters triggers such a code update, then building owners may not install submeters if their perceived savings is less than their installation costs combined with code update costs. In the interest of conservation, it would not seem wise for public

agencies to discourage submetering by requiring major plumbing code updates due to their installation.

The Seattle study also suggests that many building owners cannot retrofit apartments with submetering technology due to the plumbing configuration of older buildings. New technology to allow every type of apartment to be retrofitted is on the horizon. Wade Smith of Water Management Services, Inc. claims that his company is coming out with a system that allows each hot and cold water feed to every sink and shower in each apartment to be individually monitored. The system relies on small radio transmitters on each monitor which in turn transmit data to a larger unit, which collects data for the apartment and/or the apartment complex. Such a system would seem an attractive alternative in apartments where submetering is currently not possible. Once landlords realize that submetering is possible in these instances, they will once again need to perform a cost analysis to see if these systems are effective.

The two studies conducted by the Seattle Public Utilities indicate that submetering and direct billing achieve some level of reduction in water consumption. At the very least, they indicate the need for further studies in this area with better control as to the makeup of the study group and the control group. The Seattle Public Utilities continues to collect data in this area.

B. Denver Water Study

In 1972 only 18.5% of all residential Denver water accounts were metered. Realizing the need to conserve water, the city began a residential metering program, which resulted in 100% metering of residences by October 1992. For those accounts, which were metered, the city had used a declining block rate structure, which meant that as users consumed more water, the additional

units cost less until. This meant that the biggest users of water were paying the lowest rates for their marginal units consumed. This policy was reversed in 1990 when the city instituted an inclining block rate structure which in turn penalized large consumers for their marginal units consumed. Between 1981-1983 Denver conducted a study of 45 newly metered residences with 22 matched unmetered residences. The study found a 20% reduction²⁰ in usage by the metered accounts.

Three main variables were used in a regression analysis of the data. Seasonality was used and identified as a variable, which described the ratio of average monthly use relative to the average usage in the month of May. A weather variable was introduced which represented a combination of deviation from average rainfall for the month and deviation from average temperature. And the third variable used for the study was an aggregate of the percentage of households metered as well as an index of the effect of current conservation policies. The resulting equation was Liters (per account per day) = SI(seasonal index) + W(weather factor) + M(metering effect) and had a resulting R squared of 98%. The study found that winter water consumption was reduced in addition to summer months. This indicates that there was room for consumers to increase indoor conservation measures as well as outdoor irrigation practices. This regression analysis identified a 20% reduction in usage by these metered accounts.

C. New York Water Study

The New York City Department of Environmental Protection and the New York City Rent Guidelines Board commissioned a joint study to estimate water usage patterns in multifamily

²⁰ Impacts of Metering: A Case Study at Denver Water, Denver, Colorado, W.J. Bishop and J. A. Weber, Water Supply, Volume 14, 1996, p. 327.

buildings. A paper was published titled “The Impact of Metered Billing for Water and Sewer on Multifamily Housing in New York”²¹ in September of 1994. At the time (1994) many residential buildings were completely unmetered and instead were billed for water consumption based on an arbitrary formula which was computed by taking a flat annual rate and multiplying it by the number of units in a building. The study wanted to determine the impact of switching over to a metered billing system. It is interesting to note that even when switching over to a metered system, an annual maximum cap was proposed for usage. Thus, building owners were assured that despite switching over to a metered billing system, they would never pay more than a fixed maximum rate per unit. Gallons consumed over that maximum price would essentially be consumed free of charge as well as be discharged through the sewage system free of charge. Sewage rates were computed as a function of the water usage billed, which did not take account of total water or sewage actually consumed.

Water usage for so called metered buildings was predicted to be around 35% lower than for usage in comparable unmetered buildings. It is hard to believe that as late as 1992, with water costs rising, very few multifamily buildings in New York City were metered. There was a program underway, however, called the Universal Metering Program, which had a goal of metering all presently unmetered accounts by 1998.

To mitigate the potentially adverse impacts of metered billing on multifamily housing, in May 1993, the New York City Water Board introduced a Billing Cap Program. Under this program, eligible residential building owners may have their bills capped at \$750 for the first residential unit and at \$500 for each additional residential unit. To be eligible for the Billing Cap Program, an applicant must participate in DEP’s residential water survey program, agree to replace at least 70

²¹ The Impact of Metered Billing for Water and Sewer on Multifamily Housing in New York, Anthony J. Blackburn, Speedwell, Inc., September 1994.

percent of their toilets, repair leaks, and, if applicable, participate in the Building Superintendent Training Program offered by the New York City Department of Housing Preservation and Development.²²

It would appear that New York City was trying to promote water conservation by encouraging owners to repair leaks and install low flow devices. The policy appears to be an attempt to reduce wasted water use by requiring owners to replace most (but not all) old 7 gallon per flush style toilets with the newer 1.6 gallon per flush style. It also asks that owners repair leaks, which is most interesting considering that if the building is not metered, it would be most difficult to ascertain where the source of leaks exist. The study determined that the average level of water use is primarily influenced by the average number of people per dwelling, the number of units in a building, and the median household income of the occupants. Both the number of occupants per unit and the median household income were estimated using census tract data.

The elasticity of per-unit demand for water with respect to the estimated number of occupants was 1.5, which indicated that water consumption per unit increases at a higher rate than a proportional increase in the number of occupants. This statistic might indicate that people tend to waste more in a larger group perhaps because they feel that their individual consumption has less of an effect on the total consumed. An increase in the number of units in the building (density) by approximately 10% was found to increase the actual amount of consumption per unit by 1.1%. Again, there would seem to be some sort of “clustering effect” where more individuals whether added to one apartment or as more units added to a building, appear to consume at a greater amount than the New York model would predict individually. Income was found to have a negative relationship with consumption. The best model obtained by this study

²² Sub-Metering: The next Big Conservation Frontier?, Conserve '99, AWWA February 1999.

had an adjusted R squared of .28 with 590 observations. This is a relatively low R squared. It would appear that the researchers were satisfied with this low R squared due to the fact that so many external variables were left out of the study. The equation used was $\text{LN}(\text{use/unit}) = \text{LN}(\text{density}) + \text{LN}(\text{units/building}) + \text{LN}(\text{income})$. This form of an equation suggests that there is a non-linear relationship between use/unit and density, units/building, and income.

D. NAA Report

The most recent study on water submetering available at the time of this paper is a study commissioned by the National Apartment Association and the National Multi Housing Council entitled “Submetering, RUBS, and Water Conservation” dated June 1999. The first conclusion of this study was that tenants who pay for their water use less. Submetered properties used 18-39 percent less than properties, which did not directly bill for consumption. RUBS properties consumed 6-27 percent less than those which were not billed for consumption.²³ RUBS is an acronym for Ratio Utility Billing System. Some states allow property owners to allocate a portion of property water and sewer charges to tenants based on a formula method, RUBS. The owner determines how many square feet are in each unit, the number of occupants, and any other variables as determined by the owner or state law, which allow the owner to charge each apartment a share of these costs.

The act of “paying for consumption” had the most influential effect on reducing consumption, more than either the age of the building or the per unit cost of the water. The study suggests that just knowing that you have to pay for your consumption, regardless of unit price, was significant

in an overall reduction in consumption. Property owners stated that one of the most valuable ways to effect both the acceptance of submetering and an overall reduction in consumption was to embark on a policy of educating tenants as to the benefits of conservation. Few building owners studied made use of the consumption trend data now available to them. Were they to examine this data on a regular basis, leaks and information about peak usage periods could be obtained by building owners and managers, which would enable them to respond rapidly to leaks and excessive usage.

IV. Presentation of Data and Analysis

For purposes of analyzing the data I collected, I performed multiple linear regression analysis. This analysis attempts to explain a relationship between the dependent variable and the independent variables in the linear form $C = a + b_1(I) + b_2(J) + b_3(K)$. C represents the dependent variable which is linearly dependent on the independent variables I, J, and K. The lower case “a” represents the “Y intercept” of the equation. Lower case b_1 through b_3 represent the coefficients for each independent variable. Regression analysis attempts to find the coefficients for each independent variable, as well as the Y intercept, which explain the greatest variation in the dependent variable, C.

I have also evaluated the event that the data has a non-linear relationship. Many times data is related non-linearly as are production functions. In order to use multiple regression analysis, I transformed the data from a potential non-linear format into a linear format by using natural logarithms. Equations which had the form of $C = aM^b$, were thereby transformed into $\ln(C) =$

²³ Submetering, RUBS, and Water Conservation, Industrial Economics Inc., Doug Koplrow and Alexie Lownie, June

$\ln(a) + b(\ln(M))$. As you will see from the following analyses, I have tested the data as both a linear and a non-linear relationship.

A. Analysis and Collection of Boston Water Data

I had the opportunity to talk with Mark Medico and Tom Holder at the Boston Water Department. The idea behind the data collection was to get data on residential water consumption and to compare usage between rental properties and multifamily properties. It was necessary to first locate several streets within the water utilities territory which had a mixture of owner occupied single family homes or townhouses and multifamily rental properties. An additional constraint was trying to locate these properties with separate water meters for outdoor consumption or without any yard area, which would require watering.

An area in the South End of Boston was selected. It was composed of a mixture of single family row houses and multi family row houses. There were little or no lawn areas on these properties, so I judged outdoor usage not to be a factor. Ultimately 28 properties were selected, with only owner occupied single families being chosen from the population of single family properties. Assessor's records were obtained, and if the tax bill address was different from the property address, the property was assumed to be a rental unit. Properties which had a tax bill address which was the same as the property address were assumed to be owner occupied units. Efforts were made to exclude multifamily units, which were owner occupied, for purposes of illustrating water consumption in multifamily properties, by tenants who are not billed for consumption. Data for the properties was taken from as many available years as possible between 1987 and 1998.

After running a series of 4 different regression analyses, which included both linear and non-linear form, the top two were selected. The first regression results are:

Boston Data Results #1
cons = bedr + rental + type

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.544300692
R Square	0.296263243
Adjusted R Square	0.287123805
Standard Error	11769.10287
Observations	235

ANOVA

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>
Regression	3	13469957784	4489985928	32.4159133
Residual	231	31996221722	138511782.3	
Total	234	45466179506		

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
Intercept	2026.379409	3895.513957	0.520182813	0.603434329
Bedrooms	2240.268618	582.3983362	3.846626061	0.000154948
Rental	22275.12593	6380.255191	3.491259403	0.000575801
Type	-3573.047571	2394.728402	-1.492047102	0.137051208

The equation above, based on the predicted coefficients, explains 28.7% of the total variation in consumption. The t-statistics for bedrooms and rental appear to be significant as they are above 2.0. An increase in one bedroom corresponds to an increase of 2240 cubic feet of consumption annually for the buildings in the study. Rental properties also seem to have a positive effect on total consumption for the properties in this study. A typical rental property uses 22,275 cubic feet of water more than an owner occupied building. The type variable represents the total number of dwelling units in the building. This variable was included in an effort to determine if

there is a net effect on consumption of having more units in a building the resulting coefficient for this variable is negative, although the t-statistic does not appear significant.

The second regression form run on this data was a non-linear form, which was transposed to a linear format through the use of logs. The regression was run on the natural logs of the dependent and independent variables except for the rental variable. The results are slightly better:

Boston Data
 $\ln(\text{cons}) = \ln(\text{bed}) + \text{rent} + \ln(\text{type})$

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.62190947
R Square	0.386771389
Adjusted R Square	0.378807381
Standard Error	0.63310568
Observations	235

ANOVA

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>
Regression	3	58.39777901	19.46592634	48.5649176
Residual	231	92.5900672	0.400822802	
Total	234	150.9878462		

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
Intercept	8.210880823	0.208434811	39.39303996	1.754E-104
$\ln(\text{bed})$	0.395910029	0.140313111	2.821618207	0.005194275
rent	1.179229119	0.602355832	1.957695197	0.05146987
$\ln(\text{type})$	-0.124384727	0.476234365	-0.261183855	0.794183437

This log model above appears to explain more of the data than its linear counterpart above, with an R squared of 37.8. However, based on the t-statistics, the only coefficient from the regression which seems significant is the number of bedrooms.

An additional attempt was made to examine the consumption on single family homes relative to the change in billing frequency for Boston Water. In 1993, Boston Water changed to a monthly billing program from a quarterly system. I believed that by increasing the billing frequency, homeowners would be able to react faster to leaks and over consumption and thus reduce overall annual consumption. The results of these regression analysis are not shown because all equations tested yielded an R square of less than 2%. Because the size of the single family home sample is extremely small and because the homes selected in the sample did not contain yard areas where discretionary consumption typically takes place, I found the results of the billing regression analysis were inconclusive.

B. Analysis of Brookline Water Data

With the assistance of the Brookline Water department, I selected properties which had outdoor irrigation on a separate meter or did not have any outdoor areas that required watering. As with the Boston data, single family townhouses or homes were selected provided that they were owner occupied. These were compared against multifamily rental buildings ranging from three family houses to 120+ unit apartment buildings. Streets vary among most of the properties, however it was felt that the areas which were selected in Brookline had similar income and tenant types. Brookline data ranges from 1991 through 1998.

Brookline Data

cons = bedr + rental + type

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.992036965
R Square	0.984137339
Adjusted R Square	0.983863845
Standard Error	19585.05998
Observations	178

ANOVA

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>
Regression	3	4.14075E+12	1.38025E+12	3598.385315
Residual	174	66741975915	383574574.2	
Total	177	4.20749E+12		

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
Intercept	-6733.211873	2179.276991	-3.089654	0.002333502
Bedrooms	6767.282344	586.1981564	11.54435965	2.96841E-23
Rental	-6283.533456	3503.777496	-1.793359728	0.074652135
Type	-4124.64891	944.01283	-4.369272089	2.13765E-05

A linear regression of the data (above) with total building consumption as the dependent variable, and bedrooms, rental (1 if rental unit and 0 if owner occupied), and type (number of units in the building) yielded a R squared of 98.4%. Bedrooms appear to be statistically significant with a t-statistic of 11.54. Each additional bedroom appears to add 6,700 cubic feet to annual building consumption. Type was also statistically significant with a t-statistic of -4.36. Each additional unit in a building appears to lower total building consumption by 4,000 cubic feet of water. Thus in the Brookline case, total bedrooms and total units appear to be affecting total building consumption in opposite directions. The significance of the rental variable, however, is questionable, as it has a t-statistic of -1.79. According to this model, rental buildings have an overall decrease in consumption of 6,200 cubic feet of water as compared to the owner occupied single family units in this study.

A non-linear regression of the Brookline data was run with results as follows:

Brookline Data

$$\ln(\text{cons}) = \ln(\text{bed}) + \text{rent} + \ln(\text{type})$$

SUMMARY OUTPUT

Regression Statistics

Multiple R	0.95061995
R Square	0.90367829
Adjusted R Square	0.902017571
Standard Error	0.455100926
Observations	178

ANOVA

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	3	338.1071454	112.7023818	544.1487763	3.85792E-8
Residual	174	36.03833232	0.207116852		
Total	177	374.1454777			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>
Intercept	8.074673479	0.131456989	61.42445199	6.9761E-120	7.81521814
ln(bed)	0.837229546	0.129781889	6.451050716	1.06172E-09	0.58108034
rent	-0.661931512	0.105347995	-6.283285332	2.57648E-09	-0.86985578
ln(type)	0.493428595	0.128347543	3.84447246	0.000169224	0.24011034

It would appear that this non-linear regression also has a very high R squared of 90%. Although less than the linear model's 98% R squared, this model still may have some validity. In this model, all three independent variables appear statistically significant based on their t-statistics. Note that non-owner occupied buildings appear to consume less according to this model, based on the negative coefficient of rental. Type, or number of units, appears to have a positive impact on total consumption as opposed to the Brookline linear model which yielded a conflicting negative sign for this variable.

C. Analysis of Cambridge Water Data

I selected two streets in Cambridge, again without significant yard areas. The streets were thought to contain similar tenant types and income levels. A mixture of single family and multifamily homes was found on each street. Data was only available for 1997, and 1998. Thus the results of any of the regressions performed on the Cambridge data should be viewed as an attempt to show lower water consumption for owner occupied properties but not for an extended time series of data. Linear regression on the data yields an R squared of 20.6%. According to

this model, both type and number of bedrooms have a positive influence on total consumption. These effects appear to be statistically significant based on their t-statistics. The rental variable appears to have a small but negative coefficient, which is not statistically significant, based on the t-statistics.

Cambridge Data
cons=bedr + rental + type

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.478921229
R Square	0.229365543
Adjusted R Square	0.206012984
Standard Error	10320.42919
Observations	103

ANOVA

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>
Regression	3	3138415676	1046138559	9.821858938
Residual	99	10544614615	106511258.7	
Total	102	13683030291		

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
Intercept	-4949.28928	3032.434923	-1.632117228	0.105831743
Bedrooms	2146.175981	1006.336751	2.132661834	0.035425561
Rental	-2947.046179	2975.892519	-0.990306659	0.324438513
type	5907.162668	1822.259564	3.24166918	0.001619552

Non-linear regression of the Cambridge data yielded slightly better results with an R squared of 21.3%. Rental and type (units) were the only two statistically significant variables. Rental units appear to have a slight decrease in consumption based on the results of the regression below.

Cambridge Data
ln(cons) = ln(bed) + rent + ln(type)

SUMMARY OUTPUT

<i>Regression Statistics</i>	
------------------------------	--

Multiple R	0.486725993
R Square	0.236902193
Adjusted R Square	0.213778017
Standard Error	0.81408629
Observations	103

ANOVA

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>
Regression	3	20.36877688	6.789592292	10.24478419
Residual	99	65.61091228	0.662736488	
Total	102	85.97968915		

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
Intercept	8.150444997	0.279994276	29.10932725	2.48789E-50
ln(bed)	0.428965373	0.266750874	1.608112342	0.110995197
rent	-0.551175641	0.233594187	-2.359543484	0.020259808
ln(type)	1.091691256	0.26050945	4.190601361	6.05304E-05

D. Analysis of Combined Water Data

Linear regression appears to yield the best fit for the combined data, with a remarkable R squared of 97%. The number of bedrooms has a positive overall influence on the “average” building in the sample, which is highly significant based on the t-statistic. Type of building (number of units) appears to have a small negative impact on consumption, which is not significant. Rental, does appear to have a statistically significant positive impact on consumption. The combined data contain over 516 data points and consist of the individual data used for Brookline, Cambridge, and Boston analyses.

Combined Data

cons = bedr + rental + type

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.986469064
R Square	0.973121214
Adjusted R Square	0.972963721
Standard Error	15532.6358
Observations	516

ANOVA

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>
Regression	3	4.47216E+12	1.49072E+12	6178.826394
Residual	512	1.23527E+11	241262775	
Total	515	4.59569E+12		

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>
Intercept	-7570.776974	1033.519838	-7.325236243	9.33079E-13
Bedrooms	4366.286603	305.0256804	14.31448853	2.46584E-39
Rental	5502.074525	1527.524025	3.60195613	0.000346628
Type	-286.6282641	499.5996672	-0.573715883	0.566412001

The best non-linear form of the combined data gave an R squared of approximately 70% and was rejected in favor of the linear form above, due to the large difference of almost 30% in R squared.

VIII. Legal Review

A. Federal Perspective

The House of Representatives Committee on Health and Environment issued a report indicating that the “interests of conservation are served when residents pay for their own water. In 1996, the Committee expressed concern that the federal Environmental Protection Agency might adopt rules that might inadvertently discourage the adoption of this practice.”²⁴ The EPA is in favor of conservation and in 1998 issued a memo stating “... we support the practice of submetering to encourage water conservation and to provide an equitable method of distributing costs...”²⁵ Unfortunately, however, the EPA also views the act of the landlord charging the tenant for water as if the landlord were a water distributor or municipality. Consequently, landlords must comply

²⁴ Current Legal Status of Water and Sewer Submetering, Allocation And Billing for Apartment Properties in the United States, National Power and Water, Bill Griffin, working draft as of February 1999, <http://www.nwpc.com>

with the Safe Drinking Water Act, which includes monitoring the quality of the water. Ultimately each state has the right to determine under the Safe Drinking Water Act what the monitoring guidelines are, and therefore to determine whether or not landlords need to have periodic testing done on what is really the public water supply. “The EPA interpretation of the concept of selling water is at odds with the public service law of most states, which hold that a landlord is not selling water unless they are making a profit on the transaction. If they are making a profit, then they are in the business of selling water, and they are a regulated utility.”²⁶ If the EPA truly wants to promote conservation, they may need to rectify these two issues, and allow landlords to charge for water consumption without being viewed as utilities.

B. State Perspectives

In most states landlords are not viewed as a public utilities as long as they do not make a profit from the water distribution. Some states also view the provision of water to residents within a building as being different from providing water service to the general public. In these states, so long as water is not being provided to the general public, the owner is not viewed as a public utility. Billing for water and sewer service is legal in most states. Some states however, do prohibit the use of ratio billing (RUBS) as opposed to direct submetering. The following chart illustrates available data as to the status of submetering in several states:

State	Submetering	RUBS
Arizona	YES	YES
California	YES	YES
Colorado	YES	YES
Connecticut	YES	YES

²⁵ Current Legal Status of Water and Sewer Submetering, Allocation And Billing for Apartment Properties in the United States, National Power and Water, Bill Griffin, working draft as of February 1999, <http://www.nwpc.com>

²⁶ Current Legal Status of Water and Sewer Submetering, Allocation And Billing for Apartment Properties in the United States, National Power and Water, Bill Griffin, working draft as of February 1999, <http://www.nwpc.com>

Delaware	YES	YES
Florida	YES	YES
Georgia	YES	YES
Illinois	YES	YES
Indiana	YES	N/A
Kentucky	YES	N/A
Maine	YES	YES
Maryland	YES	YES
Massachusetts	NO	NO
Michigan	YES	YES
Minnesota	YES	YES
Mississippi	Partially	Partially
Missouri	YES	YES
Nebraska	YES	YES
Nevada	YES	YES
New Hampshire	YES	YES
New Jersey	NO	YES
New Mexico	YES	YES
New York	Partially	Partially
North Carolina	Partially	NO
Ohio	YES	YES
Oregon	YES	YES
Pennsylvania	YES	YES
South Carolina	YES	YES
Tennessee	YES	YES
Texas	YES	YES
Virginia	YES	YES
Washington State	YES	YES
Washington DC	YES	YES

The above chart was compiled at the time of publication based on data obtained from the National Apartment Association and National Power and Water. Massachusetts is the only state out of the thirty-three in the table, which prohibits both submetering and RUBS.

C. Status in Massachusetts

There is no specific state law which specifically forbids submetering. Donna Levin who was general counsel for the Department of Public Health during the administration of Michael S. Dukakis, issued an advisory ruling on July 3, 1990. Because of her advisory ruling, prohibition

of water submetering has become a de facto law. The Massachusetts Department of Telecommunications and Energy, which regulates water, electricity, and gas utilities, treats her ruling as if it were law. This ruling cites the Massachusetts Sanitary Code 105 CMR 410.180 as follows:

The owner shall provide for the occupant of every dwelling, dwelling unit, and rooming unit a supply of water sufficient in quantity and pressure to meet the ordinary needs of the occupant, connected with the public water supply system, or with any other source that the board of health has determined does not endanger the health of any potential user.

“The Department interprets the word “provide” as used in these sections to mean to supply and to pay for.”²⁷ Ms. Levin goes on to explain her rationale for interpreting the word “provide” to mean provide free of charge as follows: “The State Sanitary Code, Chapter II, has many sections which require the owner of a dwelling to “provide” services. Although the Code does not always explicitly state that the owner must pay for these services, it is obvious from the context that a service cannot be provided unless the owner pays for the service (or more accurately, unless the cost of the service is included in the rent).”²⁸ This is the fundamental reason why property owners in Massachusetts do not make any attempts at effecting water conservation through tenant billing or submetering.

The memo references another section of the State Sanitary Code 105 CMR 410.100 which says that the owner must provide things like a kitchen sink, space to install a refrigerator. The code specifically mandates that the owner provide a stove “except to the extent that the occupant is

²⁷ Advisory Ruling, Commonwealth of Massachusetts, Department of Public Health, Donna E. Levin, July 3, 1990.

²⁸ Advisory Ruling, Commonwealth of Massachusetts, Department of Public Health, Donna E. Levin, July 3, 1990.

required to do so under a written letting agreement;”. Levin argues that because the code makes specific provisions to allow the landlord and tenant to specifically negotiate the inclusion of a stove, that this implies that sections of the Sanitary Code which lack this “optionality” were therefore meant to preclude any form of optional arrangements. The Sanitary Code also provides for the ability to require the tenant to pay for fuel for heating and hot water in section 105 CMR 410.190. Section 105 CMR 410.354 (A) allows that the owner need not pay for electric and gas utilities provided that they are separately metered and that the rental agreement provides for payment by the tenant.

Residential water submetering in Massachusetts does not presently exist because of the lack of wording specifically allowing the option of the landlord to shift the cost of separately metered water to the residential tenant. There is no wording in the state law which explicitly prohibits such billing. It would seem that the state has a weak case prohibiting something that is not expressly prohibited. However, so far Federal Court has upheld the Department of Public Health’s interpretation of the State Sanitary Code. In a 1988 case, *Moore v. Lynn Water and Sewer Commission*, the Federal District court reiterated the view of the Department of Public Health as follows:

The Department of Public Health can rationally view water as essential to minimally sanitary occupancy of a dwelling, and can rationally conclude that the provision of water to every dwelling unit can be most effectively ensured by requiring property owners to provide it. Since the regulation has a rational basis, it is not unconstitutional. Memorandum and order 3-4.²⁹

D. Legislation allowing submetering in other states

²⁹ Advisory Ruling, Commonwealth of Massachusetts, Department of Public Health, Donna E. Levin, July 3, 1990.

North Carolina passed specific legislation allowing the resale of water and sewer service provided to persons who occupy the same contiguous premises. This legislation amended Chapter 62 of the Public Utilities Law by adding subsection 62-110(g) on January 30, 1997, which essentially allows landlords to bill for water and sewer charges. The new rules clearly define the premises as “an apartment complex, comprising one or more buildings under common ownership or management...”³⁰. The law requires records of billing and reports be filed annually with the Utilities Commission as well as kept on premises of the management company for inspection by officials. Rates, rules, and regulations must be posted by the management company and rules for disconnection for non-payment and billing procedure are governed by the North Carolina Utility Commission’s existing rules for utilities.

In Florida, the Public Service Commission’s rules only apply to half of the counties. The other counties are self-governing in this area. PSC law does not prohibit submetering or RUBS. Dade County (Miami) has prohibited RUBS billing. Section 367.022(8) of the Florida State Statutes exempts landlords from being classified as a public utility by stating that “Any person who resells water or wastewater service at a rate of charge which does not exceed the actual purchase price thereof, if such person files at least annually with the commission a list of charges and rates for all water service sold, the source and actual purchase price thereof, and any other information required by the commission to justify the exemption”. The Florida Administrative Code further states defines that a schedule of rates and revenue, a monthly cost/revenue analysis, and a statement listing the sources from which water and wastewater were purchased must be filed per Rule 25-30.111. Dade County, which is not regulated by PSC, has passed Ordinance 96-137 on

³⁰ Resale of Water and Sewer Service, Chapter 18, Appendix A, Chapter 62 Public Utilities Law of North Carolina,

September 17, 1996 which governs “Water Remetering”. This ordinance sets clear parameters for both tenants and owners as to submeter bills, what the bill must show, due date, late payment charges, additional charges, records, disputes, over/underbilling, submeter tests, and penalties for noncompliance. What is interesting to note is that penalties for non compliance apply to both the tenant and the landlord for violating any terms of the ordinance. Dade County has taken a proactive role in governing submetering and has not left much to chance. They have also turned registering and reporting of submeters into a source for fee generation.

Virginia’s state code makes a clear differentiation between individuals submetering and public utilities. In the Code of Virginia section 56-1.2, it states:

“Persons not designated as public utility, public service corporation, etc. – The terms public utility... shall not refer to any person who owns or operates property and provides water to residents or tenants on the property, provided that (I) the water provided to the residents or tenants is purchased by the person from a public utility..... and (ii) the person charges to the resident or tenant on the property only that portion of the person’s utility charges for the water which is permitted by section 55-248.45:1 (1993, c. 265).”³¹

This law clearly exempts owners of Virginia apartment complexes from being regulated as a public utility. Pennsylvania also has very clear legislation, which enables landlords to submeter for utilities.

The Pennsylvania Public Utility Code, chapter 66 Section 1313 states:

S 1313. Price upon resale of public utility services.
Whenever any person, corporation or other entity, not a public utility, electric cooperative corporation,.... Purchases service from a public utility and resells it to

June 21, 1996.

³¹ Virginia State Code, Section 55-1.2., c. 456.

consumers, the bill rendered by the reseller to any residential consumer shall not exceed the amount which the public utility would bill its own residential consumers for the same quantity of service under the residential rate of its tariff then currently in effect.³²

Texas has by far taken one of the most aggressive roles of all the states towards submetering by realizing that water is a scarce natural resource (especially in Texas) and encouraging conservation through submetering. The Texas Natural Resource Conservation Commission (TNRCC) has jurisdiction over water submetering under Section 13.503 of the Texas Water Code, which states:

S 13.503 Submetering Rules

Notwithstanding any other law, the commission shall adopt rules and standards under which an owner, operator, or manager of an apartment house, mobile home park, or multiple use facility that is not individually metered for water for each rental or dwelling unit may install submetering equipment for each individual rental or dwelling unit for the purpose of fairly allocating the cost of each individual rental or dwelling unit's water consumption, including wastewater charges based on water consumption.³³

Under Section 92.008 of the Property code, owners cannot cut off water (including hot water) furnished to the tenant regardless of non-payment of rent, water bill, or gas submeter bill. The property owner can however seek an eviction while maintaining utility service to the unit. The property manager must maintain records onsite as well as attach a "Lease Contract Addendum for Water/wastewater Allocation and Billing", as provided by the Texas Apartment Association, to the lease. A water bill must be issued separate from the monthly rent bill. The water bill must cover the exact same period as the owner/manager was billed from the water utility.

E. Legislation to formally allow water submetering in Massachusetts

³² Pennsylvania Public Utility Code, Chapter 66, Section 1313, c. 13:12.

³³ Texas Water Code, Submetering Rules, Section 13.503.

In Massachusetts, the Rental Housing Association (RHA) has been the main proponent of forwarding an act to the legislature, which would promote water conservation through the use of submeters in residential apartment units. Under the direction of Ed Shanahan, Executive Director of RHA, an amendment has been proposed to section 127A of chapter 111 of the Massachusetts General Laws. Ed has explained to me that this proposal has been before the Massachusetts State legislature for several years without any action so far. The wording of RHA's proposed amendment explicitly states that there shall be no other part of the Massachusetts State Code or agency which shall prohibit residential tenants from being charged for water consumption by the landlord. The amendment is as follows:

Nothing contained in the code or any other regulation issued by an agency, department, board, commission or authority of the commonwealth or any political subdivision shall be deemed to prohibit a tenant of residential premises from being obligated to pay, through use of a meter or any other device installed at the landlord's expense and designed to measure actual usage, the cost of water or sewer service furnished to such premises, nor shall any such obligation be deemed to violate standard of fitness for human habitation from time to time applied by any court. Such cost may be determined by the provider of such service or by the landlord, and the foregoing provisions shall not be construed to obligate any city, town or water or sewer company to render a separate bill relating to any particular dwelling unit. Whenever a tenant is obligated to pay the cost of water or sewer service as authorized by the foregoing provisions, the landlord shall so notify such tenant by a provision in the applicable rental agreement or otherwise.³⁴

IX. Recommendations and Conclusions

D. Conclusions from Data Analysis

I fail to understand why water should be provided free of charge and how that does tenants an overall service. I would propose that landlords have to effectively overprice apartments due to such a policy. When a landlord takes into account expenses in order to set rent pricing for the

³⁴ An Act to Promote Water Conservation, Massachusetts Rental Housing Association, provided by Ed Shanahan, January, 1999.

upcoming rental period, he or she typically look at expenses which have increased from the prior year, the rate of inflation, and current market conditions in order to determine future rent levels. If this is the case, then due to the rapidly escalating water and sewer rates in Massachusetts combined with the variability in usage from tenant to tenant, landlords may have to over estimate their water and sewer expenses for the upcoming rental year and build those inflated prices into the rent. There is no such study that I have encountered which examines this concept, but I believe that if data were gathered, one would find that water and sewer rates are a statistically significant component in rental prices. If this is the case, why not then allow tenants the ability to conserve or to over consume by their own choice? As we have seen from the studies mentioned in this paper, consumption tends to decrease when the burden of paying the water bill shifts to the tenant. Why are we not then encouraging conservation in this state?

Currently in Massachusetts multifamily residential buildings are typically billed on one meter. Because these buildings are composed of many individual households, they consume large quantities of water. Consequently, they are billed at the highest block pricing rates for their consumption. Residential block pricing was developed to encourage consumers to conserve water consumption by charging them at higher rates for each increased level of consumption. Apartment buildings are being viewed as one residential unit and consequently pay the highest rates for their water use by virtue of the large number of individual apartments that are actually contained within the buildings one municipal water bill.

Certainly apartment owners in Massachusetts have had financial incentives to install low flow devices such as toilets, restrictive showerheads and faucets. However, currently these owners

cannot encourage tenants to conserve water by obliging them to pay for their consumption. This inability to make users responsible for their own consumption encourages the waste of water and creates the need for sewage treatment plants to handle higher capacities of waste due to this excess water consumption. The excess water consumed by these apartments literally goes right down the drain.

In analyzing this data, one must realize that by selecting specific streets for the study, one is imposing some limitations on multivariable linear regression analysis. It could be argued that because of the specific street and property selection, the results are only limited and applicable to those properties chosen. However, if the argument is made that these properties are fairly representative of the rental properties as a whole, then one may argue in favor of applying these results to the overall housing population in the metro-Boston area. In performing a study such as this, there is no way to determine the historical levels of occupants in each unit. However, for purposes of these analyses, it was thought that number of occupants per bedroom would be fairly consistent in larger populations. Bedrooms was therefore used in lieu of a population measurement. Type (or units) was used in an effort to see if there is an effect of the overall size or number of units in a given structure on the overall consumption pattern.

It would appear from my data that residents who are not charged for consumption tend to use more water. Obviously, more controlled study in the Boston area is needed in order to make further determination of this effect. Most studies from other parts of the country do seem to validate my conclusions that people waste when they are not charged for use. If this is true, then the policies and laws, which promulgate this waste, need to be reviewed and changed to promote

conservation through making tenants responsible for their water usage. According to the table below, which was obtained from the Boston Water and Sewer Commission's website, total residential consumption by two unit residential properties up through multi-unit buildings was over one billion cubic feet of water in 1997, which is equal to 7.67 billion gallons of water. Most studies estimate that submetering reduces consumption by approximately 10-30%. This would mean that submetering could reduce water usage in the city of Boston by between 767 million and 2.30 billion gallons of water a year. In addition to conserving a precious natural resource, this reduction in consumption would also mean that the sewers have seen an approximately equal reduction in flow. By reducing the outflow to the sewers, we can save additional money in various communities by reducing the need for the creation of additional processing plants.

Water Consumption Total³⁵ (City of Boston)

Consumption by Land Use Code (cubic ft.) –Boston Water and Sewer Commission

Codes	1997	1996	1995	1994	1993
N/A	37,703,320	30,081,227	36,790,021	21,604,808	9,518,140
A	309,700,396	322,556,005	307,718,376	331,962,205	342,788,130
AH	70,175	59,300	198,171	123,700	38,332
C	516,508,286	518,048,344	531,603,036	517,079,990	540,080,614
CC	4,743,827	5,109,430	5,407,444	5,864,125	5,481,777
CD	5,334,563	5,032,273	5,217,632	4,863,293	4,783,634
CL	15,197,600	11,969,592	10,934,017	10,080,119	12,044,637
CM	227,953,204	222,513,469	228,250,262	227,279,495	245,805,917
E	894,672,169	916,483,920	923,060,058	952,394,310	988,039,923
EA	9,979,499	4,608,305	9,107,351	3,616,224	250,874
I	155,034,007	172,481,044	168,805,424	180,997,767	196,395,192
R1	271,890,392	262,830,751	262,150,976	262,080,316	297,409,418
R2	275,267,620	268,993,933	268,594,420	268,488,657	297,446,363
R3	338,021,723	334,243,108	331,263,995	334,994,604	377,330,779
R4	100,930,822	98,737,965	98,407,777	98,240,353	107,240,327
RC	156,437,300	156,975,027	155,205,681	150,203,423	166,801,838
RL	4,411,365	4,343,346	4,634,428	4,583,442	6,621,151
TOTAL	3,323,856,268	3,335,067,039	3,347,349,069	3,363,456,831	3,572,645,787

Legend for Codes

³⁵ <http://www.bwsc.org/about/stats.htm>

A = Apartment Building-7 Units or More
AH = Agricultural/Horticultural
C = Commercial
CC = Commercial Condo
CD = Condominium Unit
CL = Commercial Land
CM = Condominium Master
E = Exempt
EA = Clause 121A Exempt

I = Industrial
R 1 = One Family
R 2 = Two Family
R 3 = Three Family
R 4 = Four to Six Units
RC = Resid./Comm.
RL = Residential Land
N/A = Unknown

E. Support and Opposition to Submetering in Massachusetts

As no active debate has taken place recently concerning proposed submetering legislation, it is necessary to speculate as to who would oppose submetering. Tenants certainly will not be enthusiastic about paying another utility bill. However, other studies have indicated that when submetering is installed in conjunction with a conservation education program, tenants understand the need to conserve natural resources as per the Seattle Study previously mentioned. If the landlord or a third party meter monitoring company bills the tenant directly, then there may be some skepticism by tenants as to the accuracy of their bills. The legislature may need to pass specific regulations concerning the accurate billing and maintenance of these submeters. Many of the water departments are against submetering because they believe that they will now be responsible for multiples of their current client base. The people of Boston Water and Sewer explained to me that they currently have 87,000 accounts and weren't looking forward to having 587,000. However, when I explained that submeters are typically installed at the landlord's expense and a third party does the billing, they seemed to be tolerant of the idea.

It was also told to me by a variety of sources that many in the Massachusetts State House agree with the notion that providing water is a landlord's responsibility as a public health issue. The main concern appears to be that a landlord might terminate water service while the tenant is still

residing in the building. As I have shown with examples of legislation from many states, which specifically allow for submetering, non-payment of water is not cause for service termination. However, non-payment of water is cause for the landlord to begin formal eviction procedures against the tenant. That the tenant would never be in an apartment without running water. It is interesting that the act of a landlord terminating water service for non payment is taken more seriously than the electric company terminating electricity or the gas company terminating gas service. These days, it would seem to be a public health issue if either of these items were terminated for non payment. The electric and gas companies do not have to evict the tenant in order to ultimately terminate service.

The last opposition to submetering stems from the belief that submetering will be a windfall to landlords and will be unbearable by tenants. I believe this logic to be a fallacy. In fact, I would propose that if anything, the effect of billing tenants for water consumption might result in a decrease in real rent levels. Although I did not encounter any studies confirming this theory, it would seem that when landlords set rent prices for the upcoming rental season, one of the components of that pricing is water expense that they currently pay. Due to the uncertainty of knowing the amount of future water rate increases and due to the potential risk that a tenant may be very wasteful in their water consumption, landlords have to overprice this component of rent. Thus, when you remove this component, rental rates should stabilize or experience a small decline *ceteris paribus*.

Current support for submetering appears to come from landlords, submetering companies and installers, as well as environmental and conservation concerns. Landlords try to eliminate as

many variable expenses of a property as possible such as electricity and gas by turning them over to the tenants. In this way, landlords can have less uncertainty as to what their operating expenses will be for the following year, and consequently will have a better idea of what rent level they need to obtain to achieve their desired return on capital. When you force them to leave in a variable such as water, then it would seem logical that they may over estimate its costs in order to insure that they achieve their minimum desired return.

Submetering companies and installers, such as plumbers, have a financial interest in seeing that these meters get installed. However, submetering also seems to create jobs in the form of manufacturing, installation, and monitoring. Environmentalists and others concerned with the conservation of natural resources can readily see the benefits to submetering. Support should also come from taxpayers, as flows into wastewater treatment centers will be greatly reduced.

The American Water Works Association describes the accurate measurement of water as “the means by which water utilities produce revenue to cover expenses, charge each customer equitably, prevent waste of water, and minimize the load on wastewater facilities.”³⁶ I believe that the time has come for residential tenants in Massachusetts to be equitably charged for their water consumption.

³⁶ Water Meters- Selection, Installation, Testing, and Maintenance, AWWA Manual M6, Ed Seruga, 1986, p. 1.

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