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DIRECT TESTIMONY OF

PAUL L. CHERNICK

on behalf of the

CONSERVATION LAW FOUNDATION OF NEW ENGLAND, INC.

AUDUBON SOCIETY OF RHODE ISLAND

and

LEAGUE OF WOMEN VOTERS OF RHODE ISLAND

* * *

Bristol county

BEFORE THE STATE OF RHODE ISLAND

PUBLIC UTILITIES COMMISSION

* * *

PROVIDENCE WATER SUPPLY BOARD

TARIFF FILING OF FEBRUARY 1988

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* * *

June 24, 1988

TESTIMONY OF PAUL CHERNICK
on behalf of the
Conservation Law Foundation

I. INTRODUCTION AND QUALIFICATIONS

Q: Would you state your name, occupation and business addre

A: My name is Paul L. Chernick. I am President of PLC, Ir 18 Tremont Street, Suite 703, Boston, Massachusetts.

A. Qualifications

Q: Mr. Chernick, would you please briefly summarize your professional education and experience?

A: I received a S.B. degree from the Massachusetts Institu Technology in June, 1974 from the Civil Engineering Department, and a S.M. degree from the Massachusetts Institute of Technology in February, 1978 in Technology Policy. I have been elected to membership in the civil engineering honorary society Chi Epsilon, and the engineering honor society Tau Beta Pi, and to associate membership in the research honorary society Sigma Xi.

I was a Utility Analyst for the Massachusetts General for over three years, and was involved in aspects of utility rate design, costing, load forecasting, and the evaluation of power supply options.

As a Research Associate at Analysis and Inference, and in my current position, I have advised a variety of clients on utility matters. My work has considered, among other things, the need for, cost of, and cost-effectiveness of prospective new generation plants and transmission lines; retrospective review of generation planning decisions; ratemaking for plant under construction; and ratemaking for excess and/or uneconomical plant entering service. My resume is attached to this testimony as Appendix A.

Q: Mr. Chernick, have you testified previously in utility proceedings?

A: Yes. I have testified approximately sixty times on utility issues before various agencies including the Massachusetts Department of Public Utilities, the Massachusetts Energy Facilities Siting Council, the Illinois Commerce Commission, the Texas Public Utilities Commission, the New Mexico Public Service Commission, the District of Columbia Public Service Commission, the New Hampshire Public Utilities Commission, the Connecticut Department of Public Utility Control, the Michigan Public Service Commission, the Maine Public Utilities Commission, the Vermont Public Service Board, the Minnesota Public Utilities Commission, the Federal Energy Regulatory Commission, and the Atomic Safety and Licensing Board of the U.S. Nuclear Regulatory Commission. A detailed list of my previous testimony is contained in my resume. Subjects I have testified on include cost allocation, rate design, long range energy and demand forecasts, utility supply planning decisions, conservation costs and potential effectiveness, generation system reliability, fuel efficiency standards, and ratemaking for utility production investments and conservation programs.

Most recently, I testified before the Massachusetts Department of Public Utilities on behalf of the Boston Housing Authority in Docket 88-67, on the cost-effectiveness of gas conservation programs. I also filed testimony before the MDPU on behalf of the Conservation Law Foundation in Docket 86-36, on conservation program cost-recovery, and in the Petition of the Riverside Steam and Electric Company (May 18, 1988) on avoided-cost calculations.

Q: Have you authored any publications on utility ratemaking issues?

A: Yes. I have authored a number of publications on rate design, cost allocations, power plant cost recovery, conservation program design and cost-benefit analysis, and other ratemaking issues. These publications are listed in my resume.

Q: Have you advised any regulatory agencies on least-cost planning issues?

A: Yes. I am the senior economic advisor to the District of Columbia Public Service Commission in Formal Case 834, Phase II, a comprehensive review of the potential benefits of least-cost planning for both electric and gas utilities in DC. Order No. 8974 in that case, issued March 16, 1988, has been viewed as placing DC in the front rank of jurisdictions requiring their utilities to engage in least-cost planning.

I am currently the project manager and senior investigator for a least-cost planning project for the Minnesota Department of Public Service, which has a distinct set of energy-regulatory responsibilities, and also serves an intervention function similar to that often performed by PUC staff. In that project, we are estimating the potential for cost-effective conservation and load management in Minnesota.

B. Purpose of This Testimony

Q: What is the purpose of your testimony?

A: The purpose of this testimony is to compare the cost of providing water to the Providence Water Supply Board (PWSB) from a new supply, the Big River Reservoir, with the cost of controlling consumption through conservation.

II. THE COST OF NEW WATER SUPPLY

Q: What is the next supply source which the PWSB assumes it will add to its system?

A: The PWSB appears to assume that its next source of supply will be the Big River Reservoir, to be constructed by the Rhode Island Water Resources Board (RIWRB) on the Big River in Kent County. The reservoir would have total storage of 95,400 acre-feet, of which only 12,300 would be usable storage.[1] Big River would provide a maximum safe yield of 26 million gallons per day (MMgpd) of supply, of which the PWSB is projected to use 10 MMgpd in 1996, to supplement its 72 MMgpd supply from the Scituate system.[2] The Touche-Ross study assumes that construction would start on 1/1/89, that construction would be complete at 1/1/93, and that the reservoir would be full at 1/1/96.[3] Archer says 10 yrs

Q: How did you estimate the cost of water from Big River?

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1. Corps of Engineers, "Big River Reservoir Project," Appendix G, July 1981.

7 future
[illegible] Bristol 4 MMgpd
backup for OSP - 4 MMgpd

2. Touche Ross, "Final Report on Options for Financing the Big River Reservoir," May 20, 1986. Mr. Archer's testimony states that the safe yield of the Scituate is 80.3 MMgpd, and that "deliveries and commitments from the system add up to a total of approximately" 77 MMgpd. Sales in 1987 were equivalent to 62 MMgpd; it is not clear how much of the 15 MMgpd difference is due to losses, how much due to "commitments," and how much to other reporting details

3. This schedule does not appear to be feasible, and it is not clear when construction could actually start. I will use the Touche-Ross schedule for illustrative purposes.

~8+10% loss
6.4-7 MMgpd

A: The estimation process was complicated by the fact that PWSB does not appear to have any estimate of the cost of water from Big River. Such estimates of marginal sources of supply are essential in determining rate design, in evaluating conservation programs, and in evaluating other potential sources of supply. It would appear that the PWSB is not prepared to make any informed decisions regarding water supply or pricing.

Fortunately, I was able to use some information from the RIWRB and from their cost consultant, Keyes Associates, to develop estimates of the cost of Big River Water. I developed four estimates from the 1986 Touche-Ross study and from data made available by Keyes. The first two estimates rely on the Touche-Ross estimate that Big River would increase 1996 PWSB "water costs" by 2.7 times, assuming the RIWRB financed the project without state subsidies, but with tax-exempt bonds.

Q: Why did you assume the use of that particular financing scheme?

A: Most of Touche-Ross's proposed financing methods involve sizable subsidies from the State of Rhode Island (and hence from the taxpayers) to the PWSB, and therefore greatly understate the cost of the water. Since the water must be paid for one way or the other, either through rates or through taxes, it is inappropriate to evaluate the Big River project based on only some portion of the costs which would be flowed through the rates. In addition, if the State were willing to provide hundreds of millions of dollars in subsidies for the Big River project, it should also be willing to provide the same subsidies for a conservation program, which (as will be shown below) would be much less expensive.

Q: How did you use Touche-Ross's estimate of the rate effect to estimate the cost of water from Big River?

A: If 10 MMgpd of water, added to a base supply of 72 MMgpd, increases rates to 2.7 times the cost of the base supply,[4] then the increment of water must cost 14.94 times as much as the original supply, since

$$14.94*10 + 72 = 2.7*82.$$

Therefore, the estimated cost of Big River water must be 14.94 times the cost for the current supply. Unfortunately, Touche-Ross does not specify whether the "water costs" to which it refers include only supply and transmission costs, or whether they refer to water costs to consumers, which also include the cost of distribution, metering, and billing. PWSB's proposed wholesale water rate (reflecting only the supply costs) in this docket is $473 per million gallons (MMgal), or $0.173/gpd over the course of the year. PWSB's average price of water proposed in this docket is $713 per MMgal, as derived in Table 1, or $0.260/gpd.

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4. Touche-Ross may mean that Big River would increase cost by 270%, to 3.7 times the original level. I have taken the more optimistic assumption.

Multiplying these two current water cost values by 14.94 gives costs of Big River water of $2.58/gpd and $3.89/gpd, respectively.[5] This cost estimate appears to assume that the cost of Big River would be recovered over 10 MMgpd. It is conceivable, but unlikely, that the estimate is based on the assumption that the entire 26 MMgpd is sold, with the other 16 MMgpd sold to some other water system. If the cost estimate is based on sales of 10 MMgpd, the unit cost would be lower when (and if) consumption of Big River water rose to 26 MMgpd. With the higher sales figures, the annual cost would be $0.99 to $1.50 per gpd. ← add conversions

Q: What other estimates of Big River water costs did you develop?

A: I also developed two estimates of the total cost of the project, which I then converted to costs per gpd. The first estimate is based on the current working estimate of Keyes Associates of the direct cost of Big River, $262 million. I inflated this cost to the middle of the construction period (1/91),[6] added interest at 8% to 1/96, and then deflated the total cost to 1988 dollars. This calculation is shown in Table 3.

5. This comparison is not quite correct unless Touche-Ross expects the PWSB's rates to rise with inflation to 1996. The current case indicates that PWSB's costs do rise roughly with inflation, so this computation should closely reflect the original intent of Touche-Ross.

6. The 4% inflation rate is from Touche-Ross.

I then computed the investment in Big River per gpd of supply, both at the mid-term 10 MMgpd level and at the potential 26 MMgpd level. I annualized this investment with a real-levelized fixed charge rate of 4.68%, based on a 40-year life and a municipal debt cost of 8.5%.[7]

Q: What do you mean by a "real-levelized" fixed charge?

A: By "real-levelized," I mean a constant cost in 1988 dollars, which when restated in nominal dollars, has the same present value as the anticipated stream of revenue requirements. The major advantage of the real-levelized approach is that the costs of options with different lifetimes are comparable. Since the real-levelized costs are calculated as the first year of a stream which rises at the rate of inflation, the present value of a series of short-lived investments at 50 cents/gpd (real-levelized) will be the same as the present value of a single long-lived investment with the same real-levelized cost, over the same period.

The same is not true for costs levelized in nominal terms, that is, so that the current-dollar cost in each year is the same.[8] For example, suppose the levelized cost of a new supply in nominal terms would be about 80 cents/gpd, in 1988 dollars. A conservation measure with a nominal

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7. Long-term municipal revenue bonds are now yielding in the 8-8.5% range, and the cost of the debt (e.g., the underwriter's discount) raises the cost to the issuer above the interest rate.

8. Fixed-rate mortgages and leases are normally levelized in nominal terms, for example.

levelized cost of 70 cents/gpd would appear to be preferable to the new supply, at least at first glance. If the conservation lasts as long as the plant (about 30 years), the comparison is valid. However, if the conservation measure only lasts 10 years, it would not be comparable to the supply option. A comparable package of conservation would require a new conservation investment at year 10, costing 48% more than the initial measure (at a 4% inflation rate); a third investment at year 20, costing 119% more; and a fourth at year 30, for 224% of the original nominal price. Hence it is desirable to compare all costs in real-levelized terms.[9]

Q: How did you compute the 4.68% carrying charge?

A: Carrying charges for municipal (tax-exempt) financing at 8.5% interest and various life-times are computed in Appendix B.

Q: Are there any other costs associated with Big River, other than the initial investment?

A: Yes. I used the most recent available estimate of O&M expenses, inflated to 1988 dollars.

Q: What are the estimated costs of water, using this approach?

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9. Of course, it may be of little comfort to the customers or taxpayers who pay the interest for the first 20 years of a project that it may be a bargain for consumers in 2025. Nominal cost comparisons over time are also very informative, and more relevant to the assessment of macro-economic effects of the increased water rates.

A: The cost of water from Big River would be $1.71 to $0.66, using rates of 10 MMgpd and 26 MMgpd, respectively.

Q: Is this likely to be the final cost of the reservoir in 1988 dollars, if it is built?

A: No. It is my understanding that this estimate does not include mitigation measures, the dike and infiltration control system, or the replacement or opportunity costs of the land (e.g., the cost of buying other land to replace the 3240 acres of open space, or the value of selling the land for other purposes). Thus, the cost of the reservoir is likely to be substantially understated. Since the total estimated cost of the project today is several times the cost estimate reported by Touche-Ross in 1980 for a 4/91 fill date, despite a reduction in inflation projections from 10% to 4%, it seems likely that the cost estimate will increase further before the project starts construction, and further still before the project could be completed.

Q: What was the fourth method you used to estimate the cost of water from Big River?

A: For the fourth estimate, derived in Table 3, I started with the total financial requirements estimated by Touche Ross for the RIWRB-financing case. The remainder of the analysis parallels Table 2. Note that the 1986 Touche-Ross cost estimate of $203.1 million in 1986 dollars (or $219.7 in 1988 dollars) is still considerably lower than the current Keyes Associates cost estimate. However, including Touche-

Ross's additional financing costs and other costs produces slightly higher costs in Table 3 than in Table 2.

Q: Please summarize your estimates of the cost of water from Big River.

A: Table 4 summarizes the four sets of estimates. At 10 MMgpd, the costs range from $1.48/gpd to $3.89/gpd. At 26 MMgpd, the costs would fall to $0.66/gpd to $1.50/gpd. All of these costs are understated, for the reasons discussed above.

III. THE COST AND POTENTIAL OF WATER CONSERVATION

Q: How did you estimate the cost of water conservation?

A: Due to the time frame of this case, I limited my quantification to four conservation measures. Table 5 outlines the cost of conserving water by replacing selected household fixtures with more efficient fixtures which accomplish the same task while using less water. In Table 5, I estimate the cost of replacing existing fixtures with high-efficiency showerheads, kitchen faucet aerators, bathroom faucet aerators and toilets.

Q: Why did you choose these fixtures?

A: I chose these fixtures for two reasons. First of all, using these water efficient fixtures causes no discernable change in the quality of water service provided. Secondly, the water services from these fixtures accounts for approximately three-quarters of residential indoor water use.

Q: How did you model the cost and effectiveness of these measures?

A: I used detailed cost and effectiveness figures from a study by the Rocky Mountain Institute for the city of Aspen CO, attached as Appendix C to this testimony. This study estimated the cost of each fixture,[10] the number of fixtures

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10. The costs given are wholesale costs, plus shipping and installation. Retail costs would be somewhat higher, especially for the toilets, indicating that a utility-administered conversion program is likely to be much less expensive than rebates for customer-initiated installations. Also, the costs assume than none of the fixtures being replaced would ever have required replacement for reasons

per single-family equivalent (SFE) dwelling, and the savings due to each fixture per SFE per day. An SFE consists of one single-family dwelling, or a combination of multi-family housing dwellings (potentially including apartments, condos, hotels, motels, dorms, boarding houses, and the like) with equivalent total water use.

Q: Do you have any reservations about borrowing this data from a study for a different metropolitan area?

A: Yes. The cost of conservation in RMI's study probably overstates the cost of conservation in PWSB's service territory, since the ratio of fixtures (which determines the cost) to people (which determine the amount of use, and hence the savings potential) is probably much lower in Rhode Island. Also, many fixtures in Providence and other parts of PWSB's service territory are probably older and less efficient than those in Aspen. On the other hand, the RMI data seems to assume somewhat high toilet use, equivalent to about 7.6 flushes/day/person, as compared to the 4 flushes/day/person assumed by the American Water Works Association (AWWA). The high percentage of population in Rhode Island which is over 65 (14.4% for the state and 15.3% for Providence, as opposed to 8.8% in Colorado, all in 1985, and about 11.3% in the US as a whole in 1980, which is contemporaneous with the data AWWA cites) may result in a

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other than water savings: more realistically, a portion of the new fixture and of its installation cost should be credited to the cost of the new fixture.

higher percentage of the population a home during the day and hence a higher level of residential water use.

As a rough check on the reasonableness of the RMI usage estimates, I prepared Table 6, which estimates the usage of water per single-family home on the PWSB retail system. RMI estimates that total water usage per single family home in Aspen averages 500 gpd over the course of the year. However, this is largely the result of very high summer use: in the other 8 months of the year, average daily usage averages 320 gpd/household. From Table 6, Providence water usage is similar to Aspen usage, and the other three municipalities are similar to Aspen usage outside the summer season. The use of semi-annual bills probably overstates the number of domestic customers, resulting in understatements of the average usage. Overall, the RMI data appears to be applicable for PWSB, at least for this initial analysis, and until PWSB supplies detailed data on its customer mix and water usage.

Q: Are these conservation measures cost-effective?

A: Yes. The cost of the water saved, shown on line 9 of Table 5, ranges from 6 to 51 <u>cents</u> per gpd, or 2% to 34% of the costs estimated for Big River Water at 10 MMgpd. Even at full utilization, which might not occur for decades, the cost of water from Big River, as summarized in Table 4, is clearly higher than cost of replacing existing fixtures with water efficient ones.

Q: How much water can be saved through application of these technologies? no answer

A: Due to PWSB's lack of data on its customers' composition, let alone their end uses, I have had to assume a number of SFEs for the service territory. I started with the population of Rhode Island, which was 968,000 in 1985. Second, I assumed that 60% of that population resides in the PWSB service territory, based on Touche-Ross's estimate that 60% of water users are served by PWSB, giving a service territory population of 580,000.[11] Third, I assumed that an SFE includes an average of 3.5 people, which is larger than the average household size of 2.7 reported by Narragansett Electric, which serves most of the PWSB service territory. This produces an estimate of 166,000 SFEs in the service territory. By comparison, adding together the number of PWSB retail customers with 5/8" and 3/4" meters, and estimated residential customers of PWSB wholesale customers from a telephone survey of the wholesale customers produces an estimate of 135,000 residential customers. Adding in multi-family housing and other quasi-residential uses would

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11. Mr. Mainelli's testimony states that the PWSB "supplies water for approximately 500,000 people." Depending on whether he is referring to retail supply or whether he is including wholesale supply, his estimate is either somewhat higher or somewhat lower than mine.

produce a total SFE figure close to the 166,000 derived above.[12]

Q: Do these water conservation technologies have any other benefits, besides the replacement of the much more expensive Big River project?

A: Yes. There are at least five other benefits of the conservation measures: reduced PWSB water supply operating costs, reduced PWSB distribution costs, reduced sewage treatment expenses, reduced energy usage, and increased planning flexibility.

Q: How would the conservation measures reduce PWSB water supply operating costs?

A: As the amount of water PWSB must supply decreases, so does its pumping requirements, and the costs of water treatment. As derived in Table 8, the costs of pumping and water treatment are about $0.04/gpd annually.[13] If these costs vary linearly with usage, this cost should be added to the costs of the raw water supply in Table 4, since conservation

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12. According to the New England Power Pool, 47% of the housing stock in Rhode Island in 1970 was multi-family. Even if the average multi-family dwelling were only a third as large a water user as a single-family home (e.g., the multi-family housing averaged only 1.2 persons/household), the multi-family housing would add 30% to the SFEs due to single-family housing. This would raise the 135,000 single-family residential count to 175,000.

13. Pumping costs may increase more than linearly with sales, since the energy use of a pump varies with the cube of the flow rate it must maintain.

reduces raw water supply costs, pumping costs, and treatment costs.[14]

Q: How would the conservation measures reduce PWSB distribution costs?

A: Conservation would reduce the future distribution investments of both PWSB and its wholesale customers. The testimony of Mr. Mainelli indicates that the $4 million Fruit Hill project and $9 million in additional distribution projects from 1990-94 are primarily due to pressure problems resulting from load growth. If load growth is halted or reversed, many of these projects should be avoidable. Distribution operating costs (the largest category of PWSB expenses) will also be lower if less new construction is required.

Q: How would a water conservation program reduce sewage treatment costs?

A: Reduced water flow into sewers (the destination of most of the water affected by the conservation measures in Table 5) would immediately reduce the operating costs of the Narragansett Bay Commission's (NBC) sewage treatment facilities, and on the facilities of any other sewage facilities serving the affected communities. In addition, reduced load on the facilities would allow the NBC to defer

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14. Some portion of the $12 million budgeted for the treatment plant upgrade and the Longwood reservoir expansion and pumping stations, may also be avoidable, if sales stabilize or decline.

construction of additional capacity, and allow the NBC to accept sewage from other systems with inadequate treatment, avoiding environmental pollution and avoiding the need for new treatment facilities on the other systems.

Q: What are the energy advantages of the conservation measures?

A: Each of these technologies saves a substantial amount of energy, compared to the installed cost of the measure. Table 9 summarizes information from a variety of sources on the energy savings of low-flow showerheads and aerators, both of which reduce energy use by reducing hot water usage. Table 9 supports the reasonableness (or conservatism, in the sense of being pessimistic about conservation costs and effectiveness) of RMI's estimates of the cost of the devices, and also provides the basis for the useful lives I have assumed in Table 5. RMI's estimates of the water savings from the kitchen aerator and showerhead are also supported by Table 9.[15] The RMI aerator energy savings estimates are lower than those from the only other study which included aerators, while RMI's estimate of the energy savings from the showerhead are much larger than those of other studies.

Table 10 computes the annual dollar value of the energy

15. The Michigan LBL study did not differentiate between bath and kitchen aerators; it is unlikely that the figure given for the aerator was actually intended to apply to bath units.

savings for electrically-heated and oil-heated hot water.[16] I have used the lower RMI energy savings for the aerators, and the showerhead estimate closest to the average of all estimates.[17] These savings, which are likely to escalate much more rapidly than inflation, are already greater than the annual carrying charge of the showerheads and aerators. Hence, the low-flow devices more than pay for themselves in energy savings, in addition to more than paying for themselves in water savings.

Reduced water usage in toilets also reduces energy usage, by reducing the amount of water that home heating system must raise to the temperature of the living space. The actual heating may occur in the tank or in the pipes leading to the tank. Table 11 computes the savings from not having to heat the extra 3.5 gallons of water/flush by 20 degrees.[18] Even at oil/gas energy prices, the energy savings exceed the annual cost of the toilets by 35%, while the electric savings are almost 4 times the cost of the toilet. The weighted average saving is over 50% higher than

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16. The cost of water heated by natural gas should be comparable to the oil-heated costs, although I do not have retail natural gas prices for the Providence area.

17. The average of the showerhead estimates is drawn down by estimates for less efficient flow restrictors.

18. The 20 degrees might be from 45 degrees to 65 degrees. Winter water temperatures might be even colder than 45 degrees, and bathrooms are likely to average more than 65 degrees, but not all of the water will be fully warmed before it is flushed.

the cost of the toilet. Even if the water saved in the toilets were considerably less than the amount assumed by RMI, the energy savings would still be comparable to the price of the toilet.

While the installation of efficient fixtures is justified entirely by the water savings, those installations are also entirely justified by energy savings.[19] This is true from the point of view of the customers, and also from the point of view of the electric and gas utilities, whose avoided costs are comparable to their rates.[20] Thus, PWSB should seek the cooperation and cost-sharing of the electric and gas utilities with which it shares service territory, and the PUC should order the energy utilities to participate in a cooperative program.[21] A single state-wide effort to refit all plumbing fixtures would probably be less expensive and more effective than piece-meal efforts.

Q: How do conservation measures compare to the construction of Big River, in terms of planning flexibility?

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19. In addition to the energy savings discussed in the text, the water conservation program would also save energy used in pumping and treating water and sewage.

20. Narragansett Electric projects avoided costs of about 6 cents/kWh levelized over the next 30 years, while I have recently estimated the avoided costs of the Boston Gas Company over the next 20 years to be $8-$16/MMBTU (depending on whether the load is flat or weather-sensitive), equivalent to $1-2/gallon oil.

21. The NBC should also help to underwrite the program.

A: Conservation is a much superior supply planning option. The lead time is much shorter for conservation, on the order of 1-2 years, rather than the 7 years estimated just to construct Big River, even without the lengthy planning, design, and permitting phase. In addition, conservation can be added in small increments, to match annual load growth, whereas Big River represents an increment of about 34%-42% of current demand, or about 13-16 years of growth at recent load growth rates of 2.2%. The large rate increases required by Big River would depress demand, further delaying the date at which all of Big River would be utilized. Big River may come on line too late to avoid a period of serious shortages, and then may be vastly excessive for many years.[22]

Figure 1 gives an example of the timing problem which Big River could cause. In Figure 1, I assume that the current supply requirement (deliveries and commitments) is 77 MMgpd, and that the current supply is 80.3 MMgpd, based on the values in Mr. Archer's testimony, and that the requirement grows at the 2.2% annual rate at which PWSB sales have grown over the last four years. I also assume that Big River could be in operation in 1996, and that when

22. The problem is not really the excess supply, in itself, but the cost of the supply. Having an excess supply of inexpensive Scituate water has posed no problem, for example. Paying for 26 MMgpd of Big River water and using 10 MMgpd, on the other hand, increases the cost of the water from the excessive to the incredible.

its costs are reflected in rates, sales growth will fall to 1.1% annually.[23] Under these assumptions, safe yield would be less than requirements from 1990 to 1995: in 1995, requirements would be about 11% above safe yield. In 1996, with a safe yield of 104.3 MMgpd, requirements would be 91.6 MMgpd, so only 12.7 MMgpd of Big River would be utilized. If sales grew at 1.1.% thereafter, requirements would reach capacity in 2008, at which point another water supply would be needed. The additional supply would also be oversized for a substantial portion of its life, and/or would enter service later than needed.

By contrast, conservation programs can be accelerated or decelerated as changing circumstances warrant. If conservation is instituted promptly, there need be no supply shortfall in the early 1990s. There also need be no expensive supply surplus in the late 1990s. PWSB and its customers need only pay for the level of conservation programs necessary currently or in the near future, rather than for a fixed increment of supply.

Q: Are all possible methods of water conservation included in Table 5?

A: No, there are at least seven ways of achieving additional water conservation. First, more efficient devices of the

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23. I have assumed that the cost of Big River would not be reflected in rates until 1996, when it enters service. If the costs of Big River are flowed through to ratepayers during construction, sales will decline earlier and the excess capacity illustrated in Figure 1 might well be much worse.

same types discussed above are available. For example, showerheads are available which use as little as 0.5 gallons per minute, as compared to the 2.5 gallons per minute assumed in Table 5. The kitchen faucet aerator assumed in Table 5 also includes a fingertip on/off switch, which allows users to easily save water while they are momentarily occupied elsewhere (as by arranging dishes in the drainer) without losing their temperature or flow setting, or having to reach to the back of the sink. No savings from this feature (or the equivalent on lavatories) were included in Table 5. Some toilet designs use 0.5 gallons per flush, instead of the 1.5 gallons used in Table 5.

Second, additional indoor end uses offer potential conservation, including dishwashers and clothes washers. Readily available big-name dishwashers of comparable cost and quality vary in water use from 9.5 gallons to 12 gallons per cycle,[24] so savings of up to 2.5 gpd (assuming one normal wash cycle/day as average use) are available for no additional cost. The Eco-Tech dishwasher reduces water usage another 2 gallons or so, to the 7.5 gallon range, eliminates electricity use in the dishwasher, operates on cooler water, runs very quietly, and competes a wash cycle in 2-3 minutes,[25] all for a price comparable to conventional

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24. Consumer Reports 1988 Buying Guide, Consumers Union, 1987.

25. The capacity is lower than for a standard dishwasher, but the short cycle time would more than compensate for that minor disadvantage.

dishwashers, or perhaps lower. The Solar Energy Research Institute and Lawrence Berkeley Laboratory estimate that dishwashers and clothes washers which reduce water use by 30% cost no more than $30 extra, and are already available.[26] A demonstration Danish clothes washer reduces total water usage by about 40% (and a larger fraction of energy usage), compared to already efficient European models, through a number of features, including a recirculating filtered rinse. Leaks in toilets (which can be corrected by installing new toilets) alone are estimated by AWWA to waste 4.1 gpd per capita; correcting half that amount of leaks in 166,000 SFEs (at 3.5 persons/SFE) would save 1.2 MMgpd. AWWA also indicates that toilet leakage in multi-family housing of 24 gpd/person is not uncommon. Further losses from leaking faucets should also be avoidable, but I have not located any data on faucet leak frequency.[27] Rental housing (which represented 41% of the

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26. Hunn, et al., **Technical Potential for Electrical Energy Conservation and Peak Demand Reduction In Texas Buildings**, Texas PUC 1986; Usibelli, et al., **A Residential Conservation Data Base for the Pacific Northwest**, Lawrence Berkeley Laboratory, 1983. Most analyses of appliance conservation options concentrate on energy use, and hence on hot water use, rather than on all water use. For dishwashers, all water use is hot water, so there is no ambiguity in reported water savings. For clothes washers, the analyses are often less clear as to whether total water savings are proportional to hot water savings.

27. Reduced faucet leakage would reduce hot water energy use if the hot water line is the one that is leaking. Hot-water gaskets do appear to fail more often than those on cold-water lines, due to the thermal stresses on the plastic gasket. Cold water leaks in toilets and faucets increase

housing in Rhode Island in 1980) is especially subject to leakage problems, since the occupant does not usually pay the water bill. For similar reasons, condominiums may have higher leakage rates than single-family housing.

Third, commercial versions of the same measures discussed in Table 5 would save additional water, usually at lower costs per gpd saved, since commercial facilities tend to be more heavily used. The long hours of use of a commercial fixture (a shower in a health club, for example), would justify the use of a more expensive and more efficient fixture than would be cost-effective in a residential application. Almost every commercial or institutional establishment -- office, store, hotel, hospital, school, theatre -- has toilets and lavatories. Showers are also found in many commercial and institutional buildings, including health clubs, gyms, swimming pools, schools, hotels, motels, hospitals, and many other workplaces. Clothes washers are found in public and private (e.g., hospital) laundries, and in common area of many housing types (e.g., dorms, apartments). Dishwashers are found in most places which prepare and serve food, including restaurants, hotels, school cafeterias, and workplace cafeterias.

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the load on the home heating system in the winter, so reduction of those leaks would reduce space heating energy consumption.

Fourth, other commercial measures can save additional water usage. Most notably, lavatory faucets can automatically turn off after a short period of operation, saving the water normally lost when faucets are left running after the user leaves. The AWWA also notes that water use reductions are possible through adjustments in flow controls on urinals, and recycling of water in car washes. Grey water (from showers and lavatories) can also be recycled for use in toilets and urinals.

Fifth, industrial water usage can be reduced through leak reduction, flow controls (to ensure that only the required water flow is actually used, and only when it is required), recycling of water, more careful use of water in clean-up operations, reuse of cooling water, and changing production practices. An example of water recycling would be using the rinse water from one batch of material as the wash water for the next. Cooling water might well be suitable for the rinse cycle (or for use in the plant's toilets). Changing production practices could include the use of mechanical conveyors, rather than water streams, to carry product between processes. AWWA reports water savings by individual industrial facilities of up to 95%, with a 45% average for 45 firms in Los Angeles in the brief period of the 1976-77 drought, primarily due to recycling.

Sixth, there are further conservation opportunities in outside water uses, particularly in "urban irrigation," e.g., garden and lawn watering in residential, industrial, and commercial applications (especially golf courses). One general approach substitutes treated waste water (e.g., grey water from showers and lavatories, run through a sand filter, or swimming pool or cooling water) for potable water in urban irrigation. Drip and trickle watering systems, which do not lose as much water to evaporation as conventional systems, runoff, and to the wetting of sidewalks and buildings, will also reduce water use for trees and shrubs. Better controls can further reduce water usage, by limiting watering to periods when the ground needs water and when the sun and wind are not contributing excessively to evaporation. Where sprinkler systems are used, their efficiency can be increased by appropriate choices of sprinkler heads, watering intensities, spray patterns (to avoid non-planted area and to distribute water where it is needed), pop-up height (to avoid interference from nearby growth), zoning to compensate for the differing water needs of various plantings and sun exposures, and pressure regulation. Water usage can also be reduced by landscaping decisions, such as the choice of species for lawns, gardens, and shrubs; through mulching of gardens, shrubs and trees; through reduced lawn area; and through increased usage of inert materials, such as gravel and mulches.

Seventh, swimming pool water use can be reduced by covering the pool when it is not in use, reducing evaporative losses. Transparent insulated pool covers also reduce energy usage, by heating the pool in the day and retaining the warmth at night.

IV. CONCLUSIONS AND RECOMMENDATIONS

Q: What do you conclude regarding the need for water conservation on the PWSB system?

A: The high cost of Big River, the risk of shortages before Big River could be completed, and the expensive excess capacity Big River would create, all justify comprehensive conservation efforts prior to any commitment to Big River. The operating, distribution, energy, and sewage cost savings due to water conservation further increase the desirability of a major water conservation program.

Q: What actions should the Commission take in this proceeding to encourage water conservation?

A: I have three basic suggestions. First, the Commission should order PWSB to immediately start the design of a comprehensive water conservation program, including

- the determination of the mix of end uses of water on its system, and the efficiency of those end uses;
- the design and implementation of pilot programs to replace existing fixtures with efficient models;
- the determination of the incremental costs of providing additional water to end users, including the total cost of Big River water (including the effect of the average amount of excess capacity expected during the time Big River would remain the incremental water supply source), avoidable operating costs, and avoidable distribution investments and operating costs;

- the quantification of non-water benefits of water use reductions, including energy and sewage cost reductions;
- projections of water needs without a conservation program, and the effects of Big-River-related rate increases on water demand;
- economic analyses of higher-efficiency fixtures than those listed in Table 5, water-efficient appliances, and commercial, industrial, and urban-irrigation conservation measures, as compared to the total benefits of the measures; and
- negotiation with the energy and sewage utilities of a cost-sharing mechanism for a water-conservation program.

The Commission should require PWSB to report back in 6 months on its progress on achieving these goals.

Second, the Commission should attempt to encourage the responsible usage of water through rate design. Even if showerheads and faucets use less water per minute, and toilets less water per flush, the total amount of water used will still be affected by whether consumers are careful about running water only when they are actually using the water, flushing toilets only when there is a good reason to do so, fixing leaks, and limiting volumetric uses (such as soaking pots, or filling wash pails) to the quantity needed. At the present time, consumers are being given a price signal regarding the cost of water which is a small fraction of the cost of water from Big River. At the very least, the service charges should be eliminated and the volume charges should be increased to recover the same revenue. For retail residential customers, this would amount to a 50% increase in the cost of increased water use, without any further rate increases. Given the vast disparity between marginal costs and rates, the PWSB should also be ordered to prepare a proposal for implementing increasing block rates (which AWWA calls "inclining commodity rates"), so that more of the incremental usage is priced closer to marginal costs. Design of such rates requires bill frequency data, which is not available to me at this time. As a final rate design matter, PWSB should be ordered to develop pricing incentives for its wholesale customers to implement flat and inclining retail rate designs.

Third, the Commission should clearly inform PWSB that it will not approve contract for the purchase of water from Big River (or any other source of comparable cost) until PWSB has exhausted its efficiency and conservation options.

Q: Does this conclude your testimony?

A: Yes.

TABLES

Table 1: Calculation of Current Average Cost of Water

1. Net Revenue	$16,136,279
2. Total Use (HCF)	30,236,600
3. Total Use (MMgal)	22,617
4. Average Cost ($/MMgal)	$713

Notes:

[1] CDM Schedule 3

[2] CDM Schedule 2

[3] [2]*7.48*100/10^6

[4] [1]/[3]

Table 2: Cost of Water from Big River: Current Cost Estimate

1. Direct Cost 1988$	$262 million			
2. Inflated to 1/91	$295 million			
3. With Interest to 1/96	$433 million			
4. Total Cost in 1988$	$316 million			
	at 10 MMgpd		at 26 MMgpd	
5. Investment/gpd	$31.64		$12.17	
6. Annual Capital Cost/gpd	$1.48	1.70	$0.57	0.65
7. O&M in 1/88 $/gpd	$0.23		$0.09	
8. Total Annual Cost/gpd	$1.71	1.93	$0.66	0.74

Notes:
[1] Telephone conversation, James Miller, Keyes Associates.
[2] [1]*1.04^3
[3] [2]*1.08^5
[4] [3]/1.04^8
[5] [4]/MMgpd
[6] [5]*4.68%, 4.68% is the real-levelized carrying charge, municipal financing, 40 yrs.
[7] 1.7*1.04^8/MMgpd
[8] [6]+[7]

Table 3: Cost of Water from Big River: Touche Ross Total Funds

1.	Cost 1/96	$525.2 million	
2.	in 1988$	$383.8 million	
		at 10MMgpd	at 26 MMgpd
3.	Investment/gpd	$38.38	$14.76
4.	Annual Capital Cost/gpd	$1.80	$0.69
5.	O&M in 1/88 $/gpd	$0.23	$0.09
6.	Total Annual Cost/gpd	$2.03	$0.78

Notes:

[1] Touche-Ross 1986, p.8

[2] [1]/1.04^8

[3] [2]/MMgpd

[4] [3]*4.68%, 4.68% is the real-levelized carrying charge, municipal financing, 40 yrs.

[5] 1.7*1.04^8/MMgpd

[6] [4]+[5]

Table 4: Summary of Big River Water Cost Estimates

Source	Annual $/gpd At 10 MMgpd	Annual $/gpd At 26 MMgpd
Touche-Ross estimated cost increase: wholesale rate	$2.58	$0.99
Touche-Ross estimated cost increase: overall rate	$3.89	$1.50
Current cost estimate	$1.48	$0.66
Touche-Ross Required Funds	$2.03	$0.78

update from Tables 2 & 3

Table 5: Water Conservation Costs and Potential

Measures:	Aerators Bathroom	Aerators Kitchen	Shower-Heads	Toilets	Total
1. Cost/fixture	$10.26	$9.36	$16.49	$130.00	
2. Fixtures/SFE	2.60	0.92	1.74	2.50	
3. Cost/SFE	$26.68	$8.61	$28.69	$325.00	
4. Savings/SFE(gpd)	11.27	2.19	33.47	93.34	140.27
5. Investment ($/gpd)	$2.37	$3.93	$0.86	$3.48	
6. Life (years)	10	10	20	30	
7. Carrying charge	13.07%	13.07%	7.28%	5.59%	
8. Annual Cost/SFE	$3.49	$1.13	$2.09	$18.17	$24.87
9. Annual Cost ($/gpd)	$0.31	$0.51	$0.06	$0.19	$0.18
10. $/Mgal	$0.85	$1.41	$0.17	$0.53	$2.96
11. Total Savings (MMgpd)	1.87	0.36	5.56	15.49	23.28

Notes:
[1] RMI, 1987
[2] RMI, 1987; Kitchen aerators and showerheads reduced 16%
for existing efficient units, id. Appendix C.
SFE = single family equivalent
[3] [1]*[2]
[4] RMI, 1987
[5] [3]/[4]
[7] Municipal bond financing at 8.50% over lifetime.
[8] [3]*[7]
[9] [7]*[5]
[10] [9]*1000/365
[11] [4]*0.166, assumes 166,000 SFEs in PWSB service area.

Table 6: Average Domestic Use

Municipality	Usage [1]	Bills/yr [2]	Daily gal/ Customer [3]
Providence	7,854,397	63,818	504
Cranston	2,773,214	38,323	297
Johnston	839,986	10,971	314
N. Providence	1,161,211	14,346	332
Total	12,628,808	127,458	406

Notes:
[1] CDM Schedule 9, p. 1, domestic consumption HCF
[2] CDM Schedule 2, Table 2, semi-annual
[3] ([1]*7.48*100/365)/([2]/2)

Table 7: Computation of Labor Overheads

Overhead Accounts Allocated on Labor [1]	Adjusted Totals [2]
Payroll Exp Clring Acct	$21,111
Admin & Gen Salaries	$793,138
Oper Empl Pens/Benefit	$1,401,813
Maint of General Plant	$62,902
Longevity Pay Expense	$158,604
Sick Leave	$204,394
Retro Pay Expense	$26,120
Vacation Pay	$236,029
Holiday Pay	$185,031
Unemployment Comp Exp	$0
Total	$3,089,142
Labor-Related Costs	
Total	$3,120,302
Overhead: Labor Ratio	0.99
Pumping	$53,805
Pumping Overhead	$53,268
Treatment	$712,528
Treatment Overhead	$705,413

Notes:
[1] Russell, Schedule 1
[2] Russell, Schedule 1

Table 8: Operating Costs of PWSB Water Supply

1. Pumping Cost	$249,217
2. Treatment Cost	$1,343,597
3. Overheads	
3a. Pumping	$53,268
3b. Treatment	$705,413
4. Total Pumping & Treatment	$2,351,495
5. 1988 dollars	$2,261,053
6. Total Use (MMgal)	22,617
7. Total Use (MMgpd)	62
8. Pumping & Treatment Costs ($/gpd)	$0.04

Notes:
[1] Russell, Schedule 1
[2] Russell, Schedule 1
[3] Table 7
[4] [1]+[2]+[3a]+[3b]
[5] [4]/1.04
[6] Table 1
[7] [6]/365
[8] [5]/([7]*10^6)

TABLE 9: ESTIMATED LIFETIMES, COSTS, WATER SAVINGS, AND ENERGY SAVINGS FOR WATER SAVING DEVICES

MEASURE	LIFETIME	COST Retail	COST Wholesale	SAVINGS WATER gal/day	SAVINGS WATER %	SAVINGS ENERGY kwh/year
I. AERATOR						
A. BATH						
MI - LBL	10	$1.00	NA	NA	33%	140
RMI	NA	$17.55	$10.26	4.33	86%	107
B. KITCHEN						
MI - LBL	10	$1.00	NA	NA	33%	140
RMI	NA	$18.54	$9.36	1.99	38%	71
II. LOW-FLOW SHOWERHEADS						
CEC	20	$30.00	NA	10	31%	645
CFES	20	$40.00	NA	NA	50%	781
MI - LBL	10	$10.00	NA	NA	70%	650
NW - LBL	10	$40.00	NA	NA	50%	NA
NW	20	$34.20	NA	NA	35%	450
RMI	NA	$33.95	$16.49	14.55	50%	1460

SOURCES:

CEC: California Energy Commision, Measurement of the Energy Conservation Potential in CA's Residential Sector, June 1983; Water savings reflects only hot water.

CFES: Center for Energy Studies, Technical Potential for Electrical Energy Conservation and Peak Demand Reduction in Texas Buildings, February 1986.

MI - LBL: Analysis of Michigan's Demand-Side Electricity Resources in the Residential Sector, Lawrence Berkeley Laboratory, April 1988.

NW - LBL: A Residential Conservation Data Base for the Pacific Northwest, Lawrence Berkeley Laboratory, November 1983.

NW: Northwest Conservation and Electric Power Plan, Volume 2, Northwest Power Planning Council, 1986.

RMI: Rocky Mountain Institute, Least-Cost Urban Water Supply: A Case-Study of Aspen, Colorado. See Appendix C.

TABLE 10: VALUE OF FLOW RESTRICTOR ENERGY SAVINGS

	-----Aerators-----		
	Bathroom	Kitchen	Showerhead
1. Annual KWH Savings	107	71	781
2. Value of Savings at $.08/KWH	$8.57	$5.67	$62.48
3. Value of Savings at oil = $.80/gal	$2.85	$1.89	$20.78
4. Value of Savings Average	$3.94	$2.61	$28.70
5. Annual Carrying Cost per unit	$1.3~~4~~	$1.2~~3~~	$1.20

NOTES:
[1]: From Table 9, aerators from RMI, showerhead from CFES.
[2]: [1]*.08.
[3]: [1]*3413/(135000*.7)*.80, assumes 70% boiler efficiency.
[4]: 19% electric water heating, from Narragansett Electric; .19*[2] +.81*[3].

TABLE 11: ENERGY SAVINGS FROM WATER EFFICIENT TOILETS PER SFE

1. Conventional Annual Toilet Water Usage	49,275	gallons
2. Efficient Annual Toilet Water Usage	14,783	gallons
3. Annual Water Savings	34,493	gallons
4. Heating Season Water Savings	17,246	gallons
5. Savings in BTU	2,876,675	BTU
Electric Heat Savings		
6. Savings in KWH	843	KWH
7. Savings in $	$67.43	
Oil Heat Savings		
8. Savings in Gallons of Oil	31	gallons
9. Savings in $	$24.53	
10. Average Annual Household Savings	$28.01	

NOTES:

[1]: From Rocky Mountain Institute Least-Cost Urban Water Supply: A Case Study of Aspen, Colorado.

[2]: Based on 1.5 gal/flush and 9855 flushes/year.

[3]: [1]-[2].

[4]: Assuming a 6 month heating season: [3]/2.

[5]: ([4]*8.34 lb/gal)*(20 degrees F)*1 BTU/lb/degree F; assumes base water temperature of 45 degrees F.

[6]: [5]/3141 BTU/KWH.

[7]: [6]*$.08/KWH.

[8]: [5]/93800 BTU/gal; assumes 70% boiler efficiency.

[9]: [8]*$.8/gallon.

[10]: Weighted average based on 8.1% electrically heated homes and 91.9% oil heated homes, from Narragansett Electric.

THE EFFECT OF BIG RIVER ON WATER SUPPLY CONDITIONS

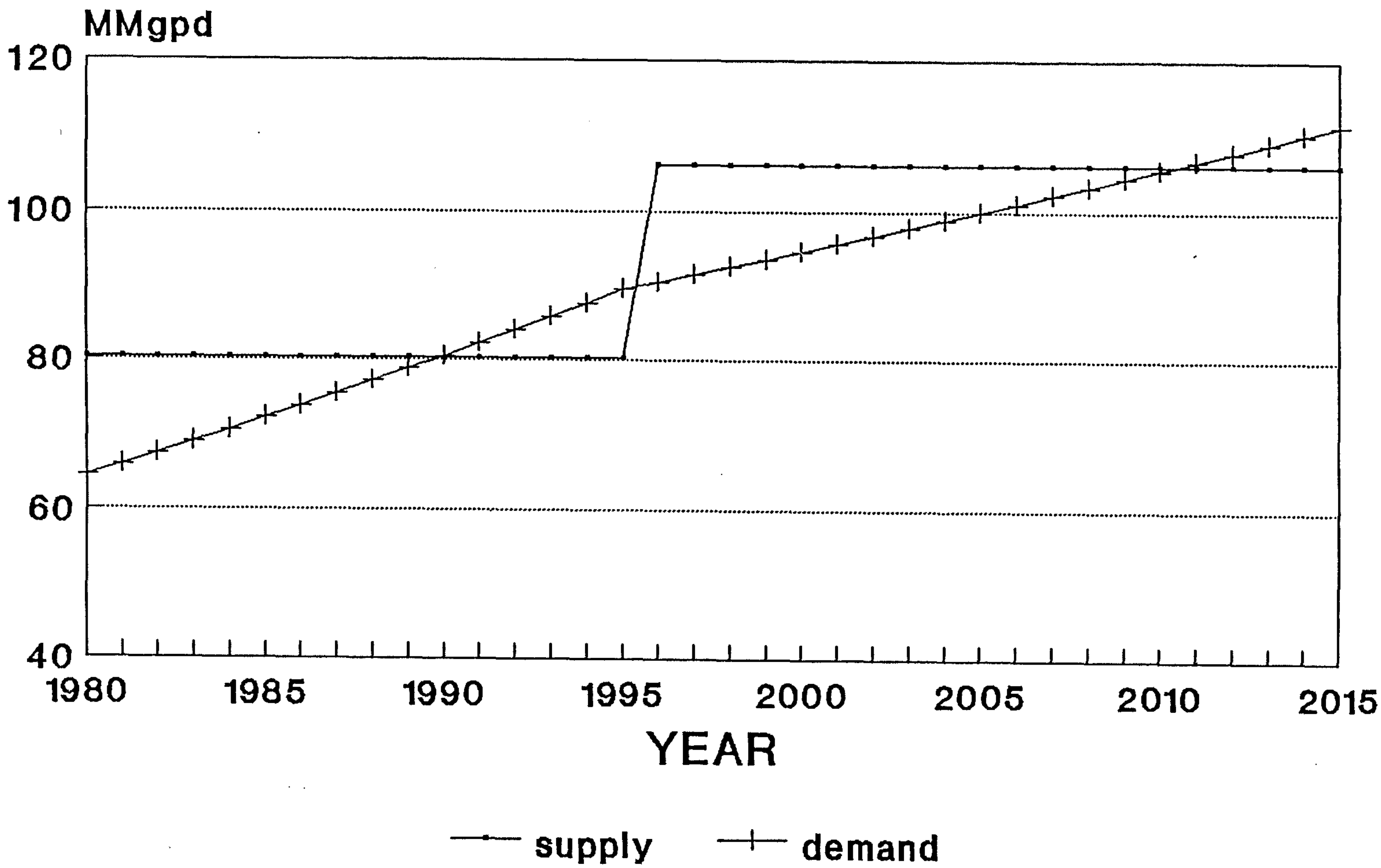

FIGURE 1

APPENDIX B:

MUNICIPAL CARRYING CHARGES

Carrying Cost of Conservation Investment: Municipal Utilities

COST OF CAPITAL

	Cost	Share	Weighted Share	Weighted Taxes
Debt	8.50%	100%	8.50%	---
Preferred	0.00%	0%	0.00%	0.00%
Common	0.00%	0%	0.00%	0.00%
Total			8.50%	0.00%(wttax)

TAX RATE:	Federal:	0.00%
	State:	0.00%
	Total:	0.00%(Tottax)
	Inflation Rate:	5.00%(IR)

LEVELIZED COST OF CONSERVATION PER $100 INVESTED

Life = 5.00 years

Year	Year-end Rate Base [1]	Depreciation [2]	Return [3]	Taxes [4]	Total Cost [5]	Nominal Value of $1 in Year 1$ [6]
0	100	---	--	---	---	---
1	80.00	20.00	8.50	0.00	28.50	1.00
2	60.00	20.00	6.80	0.00	26.80	1.05
3	40.00	20.00	5.10	0.00	25.10	1.10
4	20.00	20.00	3.40	0.00	23.40	1.16
5	0.00	20.00	1.70	0.00	21.70	1.22
Present Value at Cost of Capital:					100.00	4.32
Present Value of $1:					3.94	
Levelized cost:					25.38	23.15

LEVELIZED COST OF CONSERVATION PER $100 INVESTED

Life = 7.00 years

Year	Year-end Rate Base [1]	Depreciation [2]	Return [3]	Taxes [4]	Total Cost [5]	Nominal Value of $1 in Year 1$ [6]
0	100	----	--	---	---	---
1	85.71	14.29	8.50	0.00	22.79	1.00
2	71.43	14.29	7.29	0.00	21.57	1.05
3	57.14	14.29	6.07	0.00	20.36	1.10
4	42.86	14.29	4.86	0.00	19.14	1.16
5	28.57	14.29	3.64	0.00	17.93	1.22
6	14.29	14.29	2.43	0.00	16.71	1.28
7	0.00	14.29	1.21	0.00	15.50	1.34
Present Value at Cost of Capital:					100.00	5.86
Present Value of $1:					5.12	
Levelized cost:					19.54	17.07

LEVELIZED COST OF CONSERVATION PER $100 INVESTED

Life = 10.00 years

Year	Year-end Rate Base [1]	Depreciation [2]	Return [3]	Taxes [4]	Total Cost [5]	Nominal Value of $1 in Year 1$ [6]
0	100	---	--	---	---	---
1	90.00	10.00	8.50	0.00	18.50	1.00
2	80.00	10.00	7.65	0.00	17.65	1.00
3	70.00	10.00	6.80	0.00	16.80	1.05
4	60.00	10.00	5.95	0.00	15.95	1.10
5	50.00	10.00	5.10	0.00	15.10	1.16
6	40.00	10.00	4.25	0.00	14.25	1.22
7	30.00	10.00	3.40	0.00	13.40	1.28
8	20.00	10.00	2.55	0.00	12.55	1.34
9	10.00	10.00	1.70	0.00	11.70	1.41
10	0.00	10.00	0.85	0.00	10.85	1.48
Present Value at Cost of Capital:					100.00	7.65
Present Value of $1:					6.56	
Levelized cost:					15.24	13.07

LEVELIZED COST OF CONSERVATION PER $100 INVESTED

Life = 12.00 years

Year	Year-end Rate Base [1]	Depreciation [2]	Return [3]	Taxes [4]	Total Cost [5]	Nominal Value of $1 in Year 1$ [6]
0	100	---	--	---	---	---
1	91.67	8.33	8.50	0.00	16.83	1.00
2	83.33	8.33	7.79	0.00	16.13	1.05
3	75.00	8.33	7.08	0.00	15.42	1.10
4	66.67	8.33	6.38	0.00	14.71	1.16
5	58.33	8.33	5.67	0.00	14.00	1.22
6	50.00	8.33	4.96	0.00	13.29	1.28
7	41.67	8.33	4.25	0.00	12.58	1.34
8	33.33	8.33	3.54	0.00	11.88	1.41
9	25.00	8.33	2.83	0.00	11.17	1.48
10	16.67	8.33	2.13	0.00	10.46	1.55
11	8.33	8.33	1.42	0.00	9.75	1.63
12	0.00	8.33	0.71	0.00	9.04	1.71
Present Value at Cost of Capital:					100.00	9.29
Present Value of $1:					7.34	
Levelized cost:					13.62	10.76

LEVELIZED COST OF CONSERVATION PER $100 INVESTED

Life = 15.00 years

Year	Year-end Rate Base [1]	Depreciation [2]	Return [3]	Taxes [4]	Total Cost [5]	Nominal Value of $1 in Year 1$ [6]
0	100	---	--	---	---	---
1	93.33	6.67	8.50	0.00	15.17	1.00
2	86.67	6.67	7.93	0.00	14.60	1.05
3	80.00	6.67	7.37	0.00	14.03	1.10
4	73.33	6.67	6.80	0.00	13.47	1.16
5	66.67	6.67	6.23	0.00	12.90	1.22
6	60.00	6.67	5.67	0.00	12.33	1.28
7	53.33	6.67	5.10	0.00	11.77	1.34
8	46.67	6.67	4.53	0.00	11.20	1.41
9	40.00	6.67	3.97	0.00	10.63	1.48
10	33.33	6.67	3.40	0.00	10.07	1.55
11	26.67	6.67	2.83	0.00	9.50	1.63
12	20.00	6.67	2.27	0.00	8.93	1.71
13	13.33	6.67	1.70	0.00	8.37	1.80
14	6.67	6.67	1.13	0.00	7.80	1.89
15	0.00	6.67	0.57	0.00	7.23	1.98
Present Value at Cost of Capital:					100.00	11.10
Present Value of $1:					8.30	
Levelized cost:					12.04	9.01

LEVELIZED COST OF CONSERVATION PER $100 INVESTED

Life = 20.00 years

Year	Year-end Rate Base [1]	Depreciation [2]	Return [3]	Taxes [4]	Total Cost [5]	Nominal Value of $1 in Year 1$ [6]
0	100	---	--	---	---	---
1	95.00	5.00	8.50	0.00	13.50	1.00
2	90.00	5.00	8.08	0.00	13.08	1.05
3	85.00	5.00	7.65	0.00	12.65	1.10
4	80.00	5.00	7.23	0.00	12.23	1.16
5	75.00	5.00	6.80	0.00	11.80	1.22
6	70.00	5.00	6.38	0.00	11.38	1.28
7	65.00	5.00	5.95	0.00	10.95	1.34
8	60.00	5.00	5.53	0.00	10.53	1.41
9	55.00	5.00	5.10	0.00	10.10	1.48
10	50.00	5.00	4.68	0.00	9.68	1.55
11	45.00	5.00	4.25	0.00	9.25	1.63
12	40.00	5.00	3.83	0.00	8.83	1.71
13	35.00	5.00	3.40	0.00	8.40	1.80
14	30.00	5.00	2.98	0.00	7.98	1.89
15	25.00	5.00	2.55	0.00	7.55	1.98
16	20.00	5.00	2.13	0.00	7.13	2.08
17	15.00	5.00	1.70	0.00	6.70	2.18
18	10.00	5.00	1.28	0.00	6.28	2.29
19	5.00	5.00	0.85	0.00	5.85	2.41
20	0.00	5.00	0.43	0.00	5.43	2.53
Present Value at Cost of Capital:					100.00	13.74
Present Value of $1:					9.46	
Levelized cost:					10.57	7.28

LEVELIZED COST OF CONSERVATION PER $100 INVESTED

Life = 30.00 years

Year	Year-end Rate Base [1]	Depreciation [2]	Return [3]	Taxes [4]	Total Cost [5]	Nominal Value of $1 in Year 1$ [6]
0	100	---	--	---	---	---
1	96.67	3.33	8.50	0.00	11.83	1.00
2	93.33	3.33	8.22	0.00	11.55	1.05
3	90.00	3.33	7.93	0.00	11.27	1.10
4	86.67	3.33	7.65	0.00	10.98	1.16
5	83.33	3.33	7.37	0.00	10.70	1.22
6	80.00	3.33	7.08	0.00	10.42	1.28
7	76.67	3.33	6.80	0.00	10.13	1.34
8	73.33	3.33	6.52	0.00	9.85	1.41
9	70.00	3.33	6.23	0.00	9.57	1.48
10	66.67	3.33	5.95	0.00	9.28	1.55
11	63.33	3.33	5.67	0.00	9.00	1.63
12	60.00	3.33	5.38	0.00	8.72	1.71
13	56.67	3.33	5.10	0.00	8.43	1.80
14	53.33	3.33	4.82	0.00	8.15	1.89
15	50.00	3.33	4.53	0.00	7.87	1.98
16	46.67	3.33	4.25	0.00	7.58	2.08
17	43.33	3.33	3.97	0.00	7.30	2.18
18	40.00	3.33	3.68	0.00	7.02	2.29
19	36.67	3.33	3.40	0.00	6.73	2.41
20	33.33	3.33	3.12	0.00	6.45	2.53
21	30.00	3.33	2.83	0.00	6.17	2.65
22	26.67	3.33	2.55	0.00	5.88	2.79
23	23.33	3.33	2.27	0.00	5.60	2.93
24	20.00	3.33	1.98	0.00	5.32	3.07
25	16.67	3.33	1.70	0.00	5.03	3.23
26	13.33	3.33	1.42	0.00	4.75	3.39
27	10.00	3.33	1.13	0.00	4.47	3.56
28	6.67	3.33	0.85	0.00	4.18	3.73
29	3.33	3.33	0.57	0.00	3.90	3.92
30	0.00	3.33	0.28	0.00	3.62	4.12
Present Value at Cost of Capital:					100.00	17.89
Present Value of $1:					10.75	
Levelized cost:					9.31	5.59

LEVELIZED COST OF CONSERVATION PER $100 INVESTED

Life = 40.00 years

Year	Year-end Rate Base [1]	Depreciation [2]	Return [3]	Taxes [4]	Total Cost [5]	Nominal Value of $1 in Year 1$ [6]
0	100	---	--	---	---	---
1	97.50	2.50	8.29	0.00	10.79	1.00
2	95.00	2.50	8.08	0.00	10.58	1.05
3	92.50	2.50	7.86	0.00	10.36	1.10
4	90.00	2.50	7.65	0.00	10.15	1.16
5	87.50	2.50	7.44	0.00	9.94	1.22
6	85.00	2.50	7.23	0.00	9.73	1.28
7	82.50	2.50	7.01	0.00	9.51	1.34
8	80.00	2.50	6.80	0.00	9.30	1.41
9	77.50	2.50	6.59	0.00	9.09	1.48
10	75.00	2.50	6.38	0.00	8.88	1.55
11	72.50	2.50	6.16	0.00	8.66	1.63
12	70.00	2.50	5.95	0.00	8.45	1.71
13	67.50	2.50	5.74	0.00	8.24	1.80
14	65.00	2.50	5.53	0.00	8.03	1.89
15	62.50	2.50	5.31	0.00	7.81	1.98
16	60.00	2.50	5.10	0.00	7.60	2.08
17	57.50	2.50	4.89	0.00	7.39	2.18
18	55.00	2.50	4.68	0.00	7.18	2.29
19	52.50	2.50	4.46	0.00	6.96	2.41
20	50.00	2.50	4.25	0.00	6.75	2.53
21	47.50	2.50	4.04	0.00	6.54	2.65
22	45.00	2.50	3.83	0.00	6.33	2.79
23	42.50	2.50	3.61	0.00	6.11	2.93
24	40.00	2.50	3.40	0.00	5.90	3.07
25	37.50	2.50	3.19	0.00	5.69	3.23
26	35.00	2.50	2.98	0.00	5.48	3.39
27	32.50	2.50	2.76	0.00	5.26	3.56
28	30.00	2.50	2.55	0.00	5.05	3.73
29	27.50	2.50	2.34	0.00	4.84	3.92
30	25.00	2.50	2.13	0.00	4.63	4.12
31	22.50	2.50	1.91	0.00	4.41	4.32
32	20.00	2.50	1.70	0.00	4.20	4.54
33	17.50	2.50	1.49	0.00	3.99	4.76
34	15.00	2.50	1.28	0.00	3.78	5.00
35	12.50	2.50	1.06	0.00	3.56	5.25
36	10.00	2.50	0.85	0.00	3.35	5.52
37	7.50	2.50	0.64	0.00	3.14	5.79
38	5.00	2.50	0.43	0.00	2.93	6.08
39	2.50	2.50	0.21	0.00	2.71	6.39
40	0.00	2.50	0.00	0.00	2.50	6.70
Present Value at Cost of Capital:					97.60	20.87
Present Value of $1:					11.31	
Levelized cost:					8.63	4.68

Notes:

[1]: year 0= 100*(1-TotTax)
subsequent years= [1](t-1)-[2]
[2]: [1](t=0)/Life
[3]: [1](t-1)*Cost of Capital
[4]: [1](t-1)*wttax+[2]*(1/(1-TotTax)-1)
[5]: [2]+[3]+[4]
[6]: [6](t-1)*[1+IR]
t=year