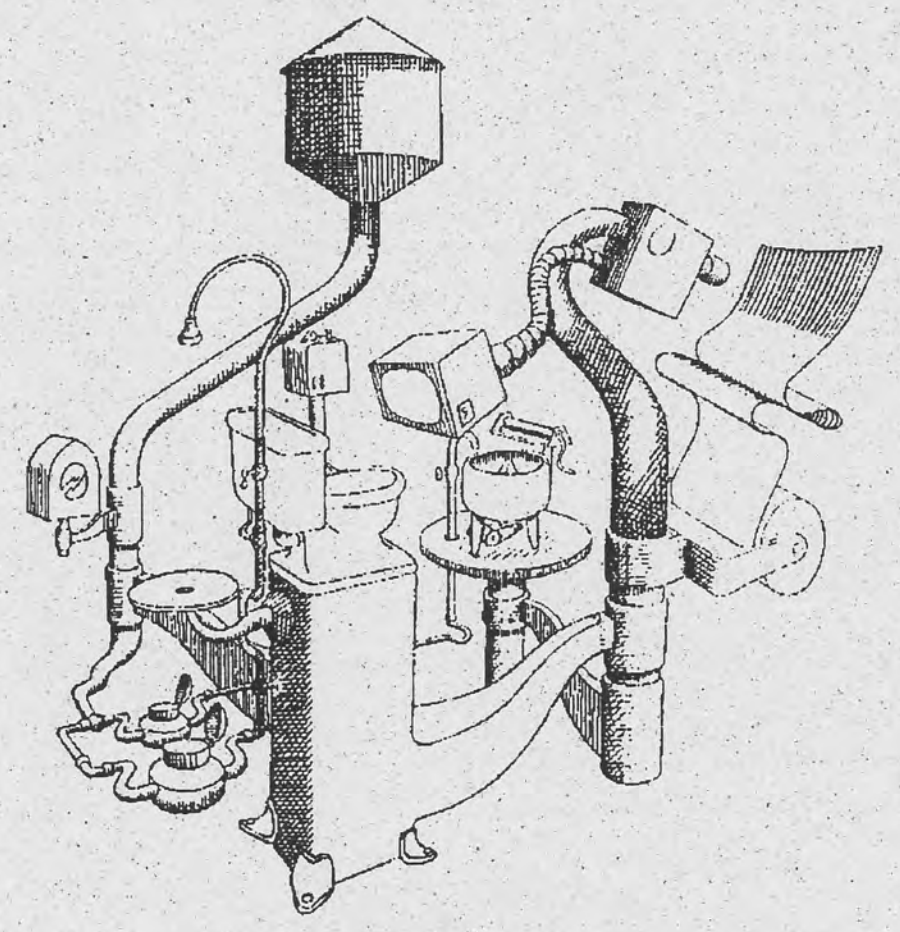
PAP-698



# Urban Water Conservation: Research Needs and Priorities

## Report of an AWWA Research Foundation Expert Workshop



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August 1993

American Water Works Association
RESEARCH FOUNDATION

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# SPECIAL REPORT

of the

# EXPERT WATER CONSERVATION WORKSHOP

to the

# AMERICAN WATER WORKS ASSOCIATION RESEARCH FOUNDATION

on

# URBAN WATER CONSERVATION NEEDS AND PRIORITIES

held on

July 22 and 23, 1993

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August 31, 1993

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## Background

As demand-side management options gain greater importance in helping balance the urban water supply/demand equation, the knowledge gap between demand-side and supply-side options becomes ever more apparent. To help address this problem, the U.S. Bureau of Reclamation and the American Water Works Association Research Foundation (AWWARF) have provided $25,000 in research funds for the purpose of identifying and determining the priority of urban water conservation needs. AWWARF assigned Kim Hout as Program Manager for the work. Ms Hout consulted with the Water Conservation Committee of the American Water Works Association (AWWA) for input at their mid-year (January 1993) meeting held in Atlanta, Georgia, as well as others. AWWARF utilized the expert workshop approach to accomplish the task. This approach involves bringing experts on a given subject together in a location where they can focus on the problem and give it undivided and intensive attention.

## Mission

Utilizing experts drawn principally from the Water Conservation Committee, the mission of the workshop team was to:

(1) identify urban water conservation research needs (projects), and
(2) determine the priority of the identified needs.

## Workshop Team Make-up

**Leader:** AWWARF selected John Olaf Nelson as the workshop leader and in late March 1993 a contract for assembling the workshop team, conducting the workshop and preparing the deliverables was entered into.

John Olaf Nelson is a civil engineer with thirty-four years of water resource experience including twenty-one years as Manager of the North Marin Water District in Marin County, California. Mr. Nelson chaired the Water Conservation Committee of the American Water Works Association from virtually its creation in 1986 until June 1992. During that time, followed by an able and energetic group of water conservation practitioners, Mr. Nelson saw the Water Conservation Committee grow from one committee with six members to a major coordinating committee with six subcommittees including several task force and liaison groups involving about one hundred active experts in all and located throughout the United States and in Canada.

**Members:** Although many qualified experts were considered, budget constraints limited workshop participants to sixteen professionals, including the workshop leader, the AWWARF Program Manager, and Steve Gordon, member of the AWWARF RAC. The expert participants were selected on the basis of their professional expertise, contributions to the water conservation literature that they and/or their organizations have made and continue to make, and wide areal distribution. The workshop members, affiliation and addresses are shown on Page i.

**Methodology Used**

Preparation for the workshop involved:

(1) setting a workshop date for July 22 and July 23;
(2) inviting selected experts and obtaining commitments from each to attend the workshop and supply written research project descriptions in their area(s) of expertise;
(3) circulating the submitted written research descriptions to the team prior to the workshop date;
(4) developing and circulating an agenda and suggested means of setting priorities for research needs identified; and
(5) working out the logistics of how to quickly commit the work product of the workshop team to hard copy to facilitate review and revision by team members.

Team members were also requested to contact others in their field of expertise and/or region for research ideas. All members of the Water Conservation Committee were also contacted and asked to contribute ideas.

By the time the workshop convened, 74 research project descriptions had been received, entered into a data base, and distributed to the workshop team. A list of the titles of these projects and the name and affiliation of the submitting party is contained in Appendix B. The submitted projects can roughly be classified as follows:

(1) industrial, commercial and institutional - 17
(2) the urban landscape - 12
(3) interior plumbing - 18, and
(4) planning, general and other - 27

The first morning of the workshop was spent talking about and identifying fundamental needs and screening and consolidating the descriptions submitted into their logical categories. Three breakout groups then took up the task of combining, editing and rewriting the research project descriptions. Eighteen major projects were identified, collated, drafted, debated and redrafted. Debating proceeded into the evening hours. The availability of three personal computers and one laser printer greatly facilitated the process.

By the afternoon of the second day, the identification and drafting process was complete enough for the team to tackle the job of setting priorities for the eighteen major research projects that had been decided upon. Each expert (excluding the AWWARF Program Manager and workshop leader) cast a ballot for each need, assigning a value of one, two or three to the project, depending on its priority (three being highest). Projects were then ranked by total value of ballots cast.

Following the workshop, the leader made final edits to the research project descriptions - reviewing significant changes with key experts. Two products were prepared: a report containing the top eight priority projects, which was submitted to the AWWARF RAC, and this more detailed report for distribution to interested parties.

## Findings

The result of the above process was a list of eighteen prioritized urban water conservation research project descriptions. The top eight are recommended to the AWWARF RAC for funding consideration at their October 1993 meeting. A list of all eighteen projects in order of priority is shown in the following table. The score in the right hand column represents the total points received in the balloting divided by the total possible points. Therefore it represents the relative consensus among workshop members on the priority assigned a given research project.

| Priority | Research Project Title | Estimated Total Cost | Score |
|---|---|---|---|
| 1 | Residential End Uses of Water | $550,000* | 100% |
| 2 | Industrial, Commercial, and Institutional End Uses of Water | 400,000 | 87% |
| 3 | Performance Standards for Water Efficient Toilets | 200,000 | 85% |
| 4 | Integrated Resources Management - The Next Step | 150,000 | 82% |
| 5 | Water Conservation Pricing | 200,000 | 72% |
| 6 | Water Saved by Residential Water Conserving Landscapes | 175,000 | 69% |
| 7 | Water Saved by Water Efficient Toilets | 200,000 | 69% |
| 8 | Integrating Drought Management and Long Term Water Conservation | 175,000 | 67% |
| 9 | Performance Standards for Water Efficient Appliances | 100,000 | 67% |
| 10 | Effectiveness of Public Information That Promotes Water Conservation | 200,000 | 67% |
| 11 | Regulatory Incentives to Promote Water Conservation | 125,000 | 64% |
| 12 | Appropriate Technology for Cooling Water Use | 250,000 | 62% |
| 13 | Water Saved by Retrofitting Non-Residential Rest Rooms | 130,000 | 62% |
| 14 | Water Saved by Non-Residential Water Conserving Landscapes | 125,000 | 59% |
| 15 | Sub-Surface Drip vs. Conventional Irrigation Systems | 125,000 | 56% |
| 16 | Urban Water Conservation Financing Mechanisms | 55,000 | 51% |
| 17 | In-Ground Systems vs. Irrigation With Hose and Sprinkler | 200,000 | 51% |
| 18 | Meter Sizing for Reduced Flows | 120,000 | 51% |

* Workshop experts expect AWWARF's share can be reduced to $330,000 based on federal, state, and water utility matching funds that are expected to be available.

Individual write-ups for each of the eighteen priority projects in the order of priority (number one being the highest) are contained in Appendix A.

Funding requirements for the top eight projects were estimated to total $2,050,000. Funding requirements for all eighteen projects total $3,480,000.

**Estimation of the "Residential End Uses of Water" was selected as the highest priority project by each and every expert in the workshop. This clear mandate identifies this project as the highest and most urgent need in the urban water conservation research area. The fact that all workshop participants were in unanimous agreement on this point is clearly unique and noteworthy. The total estimated cost for this project is $550,000. Workshop participants were of the opinion, however, that about 40 percent of the cost of**

**this priority project can be raised through the financial participation of federal and state agencies and large water utilities - leaving about $330,000 for AWWARF to finance.**

Funding support for a number of other projects is also believed likely by many of the workshop members. The second priority project, Industrial, Commercial and Institutional End Uses of Water is a case in point. Utilities serving some large metropolitan areas are believed to be very interested in this research area. Priorities 3, 7, and 13, projects involving water efficient toilets, should attract funds from trade associations and standard setting groups interested in plumbing fixtures and systems. Priority 9 involving water using appliances is also of interest to large energy utilities. Priority 12 involving cooling water use should attract the interest of certain industrial associations. Priorities 6, 14, 15 and 17 are all of interest to the "green industry" and should attract the attention of trade and professional groups interested in that area.

## Continuing the Process

The need for definitive research efforts in the field of water conservation has existed for some time. With the ever increasing economic and environmental cost of building water facilities, the trend toward greater integration of water resources including demand-side management and recycling (integrated resource planning) in balancing supply and demand, and increased public awareness, the need for analysis and research is even more evident. The AWWARF Urban Water Conservation Workshop and the resultant identified research needs and priorities can help many groups and agencies determine research efforts in the coming years.

With the relatively fast occurring changes in the field of demand management, review of urban water conservation needs and priorities should be done annually. This report, as well as other efforts currently underway (a list is available from AWWARF), continues to add information to the water conservation field. A few ways to keep identification of research needs current are described below.

**AWWARF Process:** AWWARF's RAC is charged with recommending research projects to the Foundation's Board of Trustees. The RAC reviews hundreds of research ideas each year during their fall meeting. Any research idea originating from AWWARF subscribers (subscribers support AWWARF research with annual contributions), AWWA members, or other agencies and interested parties must be submitted to AWWARF by mid-August for consideration at that year's fall meeting of the RAC. Any person, group or agency with an idea is welcome to submit same for consideration. The following January, the Board of Trustees of AWWARF then meets to decide which projects will be funded. This sets the research agenda of new projects for the calendar year. Requests for proposals from potential researchers are then prepared and are generally sent out by March.

**AWWA Process:** Research needs and ideas originating from any AWWA committee (such as the Water Conservation Committee) or task group within AWWA are submitted to the AWWA Research Division by July 15 of each year. A special Research Prioritization

Committee then meets to prioritize research recommendations by August 15 of each year. These recommendations are passed on to the AWWA Project Review Committee (consisting of the AWWA Council Chairs and members of the AWWA Research Prioritization Committee) to be finalized. Final recommendations from AWWA are submitted to AWWARF by September 1 of each year and become part of the project proposals considered by the RAC.

**Other Agency Processes:** The research needs and priorities contained in this report should also be useful to other agencies and organizations making decisions about funding water conservation research, such as the U.S. Bureau of Reclamation, the U.S. Environmental Protection Agency, the U.S. Corps of Army Engineers, other federal agencies, state agencies, regional authorities, water research centers, universities, water utilities large enough to support their own research, private foundations, etc. Other agencies and organizations are welcome to consult with AWWA and AWWARF to find out what new efforts are underway or what new research priorities have emerged. Collaborative research often evolves.

**Acknowledgments**

Lastly, on behalf of the project sponsors (AWWARF and the U.S. Bureau of Reclamation), the AWWARF Project Manager, and this writer, many thanks are due for the timeless and unselfish contributions made by all those who helped with this effort (refer to Page i and Appendix B). For relatively few dollars, a major piece of work was accomplished in a very short period of time. This effort will serve as an important guide to where limited and hard-to-come-by research dollars should be spent in the urban water conservation area.

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# APPENDIX A

# DETAILED DESCRIPTIONS OF EIGHTEEN HIGHEST PRIORITY PROJECTS

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## PROJECT TITLE: RESIDENTIAL END USES OF WATER

### Project Background

In 1984, the U.S. Department of Housing and Urban Development (HUD) released a report on typical residential indoor water use based on data collected from 200 households at eight demonstration sites around the nation. The purpose of the study was to document how people use water in their homes and how water demand can be reduced using a variety of conservation measures. The study has stood as the principal "standard reference" for planners.

The HUD study, however, needs to be updated and expanded for several reasons. First, over the past ten years, water use has changed as new products have been introduced into the market and a growing number of plumbing fixture and appliance retrofit and replacement programs have been developed and implemented. Second, federal, state and local regulations requiring efficiency will result in substantial water savings across the country over the next 20 years as old fixtures are replaced with new efficient models. Without a baseline understanding of what type of fixtures are currently installed, how much water they use, how often people use them, etc., utilities may find it difficult to reliably predict future adjustments to water demand. Such changes in future demand need to be understood as they have direct implications for future capital facility planning decisions and costs. Third, residential outdoor water use also needs to be studied and included in order to update prevalent a priori assumptions.

Unfortunately, up to now, few measurements of actual water use for various indoor and, particularly, outdoor water use activities have been made. Studies aimed at quantifying residential end uses of water have relied almost entirely on billing records. The separation of total residential water use into indoor and outdoor components is frequently based on estimation techniques such as the minimum-month method or based on customer-reported information about the presence or absence of outdoor water-using activities. Even when a reliable estimate of use is derived, its further disaggregation into specific end uses (such as toilet use, shower use, clothes washing, etc.) has to rely on engineering estimates. These engineering estimates need verification and updating.

### Project Goals

The overriding objective is to increase the ability of water planners to accurately estimate the potential water savings and cost-effectiveness of conservation programs. The specific goals are:

1) to improve on engineering estimates of residential end-uses of water (i.e., water used by specific indoor and outdoor water-using appliances, fixtures, and irrigation practices and systems)

2) to identify the variations in water use for each fixture, appliance and system according

to such factors as product "generation" (age), product usage (time, frequency) by customer, product operating and flow type, household type (single or multi-family), home age (construction year), socio-economic/demographic characteristics and other determinants.

## Research Methodology

Improvements in quantifying the significant end uses of water can be achieved by econometric analysis using statistical methods to estimate end uses. The sample of customers for this study should be randomly selected and sufficiently large to (1) ensure adequate representation of all types of customers (such as single family and multi-family) and (2) achieve an acceptable level of confidence in the results.

Electric utilities use a form of econometric analysis, called conditional demand analysis (CDA), for estimating residential unit energy consumption coefficients. The CDA method uses individual billing consumption data and survey data to derive estimates of consumption by end use.

The CDA model specification is based on two assumptions. The first is that the observed customer's use in any given month is a summation of uses by all appliances, fixtures, and systems. The second assumption is that water use by each appliance, fixture, or system depends upon a set of external factors (such as number of persons, home value, weather, price, etc.) A useful feature of the CDA technique is that it can be used to provide econometric estimates of the average water usage levels of individual appliances, fixtures and systems without the necessity of directly metering end use.

It is proposed that two areas be considered for the study. One from the West Coast and one from the East Coast. The sample sizes for the CDA should be about 500 dwellings for each study area.

In addition to the CDA, a sub-sample of homes will be fitted with micro-meters to assist in validating and calibrating the statistical findings. The micro-meters will measure quantities of water used inside for toilets, showers, and major appliances and outside for irrigation of lawns and other irrigated landscape. About 50 homes in each study area will be fitted with micro-meters and monitored for at least one year.

## Final Product

The final product will be two reports: a summary report containing all findings and a detailed report with appendixes, which contains not only the findings but detailed methodology, analyses, and appropriate data. It is expected that the summary report will replace the HUD study summary as the "standard reference" for water conservation planners.

## Project Funding

The total estimated cost for this study is $550,000. Workshop members believe 40 percent of this amount can be raised from federal, state and interested water utilities, leaving about $330,000 as AWWARF's funding share.

No. 2

## PROJECT TITLE: INDUSTRIAL, COMMERCIAL, AND INSTITUTIONAL END USES OF WATER

## Project Background

The lack of measurements of the quantities of water used for sanitary, process, cooling, and miscellaneous uses (as well as the substantial variance in water use) are obstacles to the development of reliable estimates of water conservation savings for non-residential uses of water, ie. industrial, commercial, and institutional (ICI) uses. Engineering estimates in this area are of limited validity because end uses vary so dramatically. The potential error in estimating ICI end uses can often exceed the magnitude of the expected conservation effect.

The purpose of the proposed study is to increase the information base on ICI end uses of water and to increase the ability of water planners to accurately estimate the potential water savings and cost-effectiveness of conservation programs.

## Project Goals

The goals of this project are to:

1) Create a database of existing information about ICI water use including information on various end uses where available and detailed case examples of documented water savings.

2) Determine who the important water utility served ICI customers classes are, both in terms of amount of water used and number of customers.

3) Apply econometric analysis techniques to disaggregate billing data into end uses for applicable ICI customer classes.

4) For select ICI customers conduct pilot studies and develop the methodology for understanding how water is used and where water saving potential exists.

5) Improve on engineering estimates of ICI uses of water including end uses and increase the ability of water planners to accurately estimate the potential water savings and

cost-effectiveness of ICI conservation programs.

## Research Methodology

1) Survey expert practitioners in both the public and private sector and bring together information on ICI water use by class (including available information on end-uses by class) into a single database. Collate the database to optimize its usefulness for water conservation planners. Protecting customer identity as necessary, collect information on, and display details of case examples where significant water use efficiencies have been achieved.

2) Survey AWWA utilities requesting information on the water use of their top (say 25) ICI customers. Segregate the data using the Standard Industrial Classification (SIC) codes and analyze same to determine profiles of ICI use for reference by others and to help determine how to orient and focus the research project funds.

3) Utilizing the information obtained in steps 1 and 2, identify "Category A" ICI customers for which sufficient information exists to make it likely that econometric analyses will yield reasonable estimates of end uses. Identify Category B" ICI customers for which little information exists but which are suspected to employ end uses of water for which similarities in use are suspected to exist. Exclude large industrial users including large cooling water uses (typically two digit SIC users) such as steel, energy production, paper board, chemical, petroleum production, etc. These are beyond the scope of this study and would require case-by-case analysis.

4) For "Category A" ICI customers, apply econometric analysis using statistical methods to estimate end uses. The sample of customers selected for the analyses should be sufficiently large to (1) ensure reasonable representation and (2) achieve an acceptable margin of error in the results. Conditional demand analysis (CDA), similar to the approach used by many electrical utilities, which relies on individual customer billing data augmented by survey data, would be employed to derive estimates of end uses for ICI "Category A" users.

5) For "Category B" ICI customers, a select group of those ICI classifications deemed to be important for study (based on the findings of Step 1 and 2) would be selected for detailed case study. Funds would permit only one ICI customer in each selected ICI customer class to be studied in this step. Each case study would involve a thorough study of the operation including use of submeters as needed to determine all important water flows and their frequency. Dependency on variables affecting water use would be developed by surveying the operation with input from the customer. These pilot studies would serve as examples of how to go about analyzing and determining cost-effective savings. Benefit analysis would include energy and waste disposal costs as appropriate.

## Final Product

1) An ICI database containing available information in ICI water use (including end uses to the extent known) and including documented case examples.

2) A report identifying the most important water utility served ICI customers, including profiles on water use based on billing records and group statistics.

3) A report showing the findings of the econometric analyses and the case example pilot studies.

## Project Funding

This study is expected to cost $400,000.

No. 3

## PROJECT TITLE: PERFORMANCE STANDARDS FOR WATER EFFICIENT TOILETS

## Project Background

The relatively fast development and application of ultra low flush (ULF), 1.6 gallon per flush (gpf), water closets in buildings of all types has raised concern about their functional performance and effectiveness in transporting wastes. Coupled with these concerns is the serious problem of poor performance flappers and water control valves in existing toilets. Current performance requirements are not stringent enough to differentiate between excellent and only fair flushing performance. Since many water utilities are promoting the use of 1.6 gpf fixtures in all applications, it is important that performance information be known.

The lengthy consensus process leading to standards precludes the rapid development of requirements and test specifications needed. This project will accelerate the entire performance standards setting process and serve as a reference document for standard writing bodies, federal agencies, and others.

## Project Goals

The goals of this project are:

1) Develop performance requirements and a laboratory test methodology capable of predicting field performance of water closets in four building classifications: (1) one and two family dwellings, (2) multi-family dwellings, hotels, motels, and small business offices, (3) office buildings, factories, and industrial facilities, mercantile and

restaurants, and (4) places of assembly, schools, institutions, transportation centers, and stadiums.

2) Report on the effectiveness of ULF fixtures in transporting wastes taking into account discharge flow, pipe size, slope and roughness. Recommend alternative designs, where required, for good transport.

3) Determine functional performance for all types of water closets and operating durability of water closet components with particular focus on flapper valves, including the influence of water quality.

4) Establish performance requirements for flappers and retrofit devices.

## Research Methodology

1) Review literature on laboratory and field testing of toilet fixtures.

2) Develop and determine the priority of a list of desirable criteria for flushing performance.

3) Develop standard laboratory tests which can be used to document performance criteria.

4) Assemble a wide variety of 1.6 gpf fixtures covering the spectrum from several known poor performers to several known excellent performers.

5) Conduct laboratory testing and data collection to delineate performance levels for inadequate, adequate, and superior flushing performance.

6) Gather the maintenance records from a selection of dwellings and other buildings to enable the establishment of fixture failure rates for 3.5 gpf and 1.6 gpf toilets. Identify fixture designs with acceptable performance and measure their flushing efficiency with the proposed test.

7) Concurrent with the study of maintenance records as defined in Task 6, establish drainline failure rates. Investigate repetitive failures to evaluate the condition of the drainline and determine its impact, if any, on waste transport.

8) Plan and conduct a series of laboratory tests simulating the deficient drainline conditions to determine the relative effectiveness of 3.5 and 1.6 gpf toilets in these instances.

9) Modify testing procedures and calibration tests as necessary.

10) Develop final testing procedures and performance standards to define flushing performance for each of the four building classifications.

## Final Product

Prepare a test specification for use by product standards committees, regulating agencies, or governing bodies. The specification shall address functional performance and transport of wastes. Prepare guidelines for the successful installation of ULF products in existing buildings through the assessment of the installed water supply and drainage system.

## Project Funding

The estimated cost for this work is $200,000

No. 4

## PROJECT TITLE: INTEGRATED RESOURCES MANAGEMENT - THE NEXT STEP

## Project Background

There is more and more recognition of the need to approach conservation in the context of total water resources management.

AWWA has begun to address this need with the research conducted by Dr. Jan Beecher. AWWARF has a project underway to develop the first step - a guidebook on Integrated Resources Planning. This project addresses the next step, how water managers go from planning to management. This project will extend the initial work to encompass opportunities for interagency partnerships to co-fund conservation projects that have multiple benefits, inclusion of externalities, and a fuller description of the public participation process.

Budgetary constraints make any single purpose project, including conservation difficult to justify. Multi-objective projects are much more favorably received. Integrated Resources Management (IRM) is the tool that more and more water agencies are looking to for the optimization of water supply, waste water, environmental, economic, and other related benefits.

Water districts need guidance on the most efficient way to implement IRM. This study will include examples of successful approaches, how the water suppliers accomplished it, who they involved, and how they dealt with questions of interagency jurisdiction.

This work is particularly timely with the possibility that IRM may be included as a provision of the Clean Water Act.

## Project Goals

1) Identify the types of resources that should be included in IRM (e.g. water supply, waste water treatment, demand management, etc.). Provide guidance on how secondary costs and benefits, including externalities, can be identified, quantified when possible, and factored into the IRM (e.g. energy, water quality, distribution system impacts, environmental and social resources).

2) Provide examples of successful approaches to public participation in the IRM process.

3) Provide a methodology for identifying multiple objectives (e.g. deferring the need for capital expansion, reducing energy costs, creating local jobs etc.).

4) Demonstrate how to have interagency partnerships to co-fund conservation projects that have multiple benefits.

5) Develop a concise, understandable guidebook for water managers that provides specific examples and guidance on how to conduct Integrated Resources Management.

## Research Methodology

1) Coordinate with earlier work sponsored by AWWA, AWWARF, and others to identify the best examples of Integrated Resources Management conducted by water districts.

2) Conduct personal interviews of key participants in successful Integrated Resources Management, including non-water-district personnel.

3) Correlate the findings with the extensive research conducted on Integrated Resources Management as carried out by energy utilities.

4) Draft the Integrated Resources Management Guidebook.

5) Have the Draft Guidebook reviewed by a subcommittee of AWWA's Water Conservation Committee.

6) Make appropriate revisions based on the review.

7) Prepare the final integrated Resource Management guidebook for AWWA publishing.

8) AWWA publish final guidebook.

## Final Product

A concise, understandable guidebook for water managers that provides specific examples and

guidance on how to conduct Integrated Resources Management.

**Project Funding**

This work is estimated to cost approximately $150,000.

No. 5

## PROJECT TITLE: WATER CONSERVATION PRICING

**Project Background**

Price has been used successfully to reduce water demands during severe shortages. Many water professionals believe that price can also be used to bring about efficient long-term conservation. A number of utilities across the country are now using tiered pricing (increased block rates) and seasonal or excess use charge structures. Others believe high levels of long term conservation can be achieved without resorting to price differentiation. Alternative rate structures have been described in a manual recently published by AWWA.

However, few suppliers have a good empirical basis for setting the blocks or charges and overall rate design. Many designs are not related to costs or to conservation goals of the community. Without analysis of appropriate costs and development of scenarios using those costs, and without input from the community on goals, such rates may be unnecessary or fail to yield the desired effects and in some cases might increase overall water use.

**Project Goals**

1) To document case studies of the effectiveness of rate structures in reducing water use. These case studies should include reductions by non-residential users as well as residential users. They should also differentiate the effects on interior or year-round use from effects on exterior or summer use. A discussion of the use of elasticity data will be included. Case studies involving high levels of conservation without price differentiation will be included so that suitable situations for using (or not using price differentiation can be assessed.

2) To document appropriate ways of analyzing costs and developing scenarios, with focus on cases involving public participation which are judged well done and result in effective conservation rate structures.

3) To develop principles for setting rate parameters (e.g., how wide and tall to set blocks and surcharges) to meet water use and revenue goals effectively.

4) To propose principles for public participation in rate setting.

## Project Methodology

Several case studies will be used in the research project. The case studies will be selected initially through interviews with members of the AWWA Water Conservation Committee, members of the Rates and Charges Subcommittee, and consultants working on related AWWARF projects. A number of these interviews as well as the case studies will be used in documenting approaches to cost analysis and scenario development and the resulting principles.

In addition to achieving the project goals, the project will also:

1) Review literature on price elasticity, specifically focussing on how price was used during severe shortage and drought situations.

2) Analyze existing conservation oriented price structures and the effect they have had on water consumption for study areas.

3) Analyze costs of providing summer use water and/or peak day water compared with costs of providing average day water.

4) Show how a utility could forecast the savings attributed to the synergy of rates and conservation programs.

5) Discuss the circumstances and ways in which marginal costs could be appropriately used as rate parameters.

6) Develop a way to extrapolate the net effect of price and projections of long-term conservation.

7) Discuss the desirability of rate structures which individualize bills based on contribution to peak seasonal demands (or peak day demand for large customers) rather than using only customer class contributions. Examples of the former would include excess use charges and goal billing based on persons per household or other customer characteristics.

8) Review literature on public participation in rate making.

## Final Product

The final product of this research effort will be a report that documents the study goals, methodology, and results. The report will also provide water managers with the tools needed to help extrapolate the results to their specific area in order to project the net effects of price on long-term conservation.

## Project Funding

This project is estimated to cost $200,000.

No. 6

## PROJECT TITLE: WATER SAVED BY RESIDENTIAL WATER CONSERVING LANDSCAPES

## Project Background

Water conserving landscapes have been promoted in several states by water utilities and certain members of the green industry for a number of years. However, little information has been developed on water use differences between water conserving landscapes and traditional landscapes in single family detached home settings. Preliminary studies indicate savings up to 40 percent of outdoor water use.

## Project Goals

The goals of this project are to:

1) Recommend criteria defining water conserving landscapes and traditional landscapes for the typical single family detached home situated in four different climate areas in the United States.

2) Make a statistically valid comparison of water used by water conserving and traditional landscapes in each of four communities located in four states each in a different climate area.

3) Develop a model that can be used to predict water use for water conserving landscapes versus traditional landscapes for each of the four research sites.

## Research Methodology

1) Select four willing participating utilities in four different states with distinctively different climates, representing major climate zones in the United States.

2) Determine criteria defining water conserving landscapes and traditional landscapes for typical single family detached homes in each of the areas.

3) Determine variables that affect irrigation and other factors necessary to identify the outside irrigation portion of single family home water use. These shall include water use determined by separate meter reads during each of the three peak irrigation

(generally summer) months for each home; water use during the non-irrigation season (generally wintertime water use) for each home (bimonthly reads will suffice for the latter); lot size; area of softscape; lawn area; relative slope of land; relative shade on softscape area; aesthetic evaluation of landscape; type of irrigation system, including information on presence of automatic controls; value of home; occupancy levels during both the peak irrigation months and the non-irrigation period; presence of swimming pool or other water feature which is predominantly used in the summer months; and identification of leaks or extraordinary use during two metered observation periods.

4) Selection of a representative sample of single family detached home water conserving landscapes and a corresponding number of single family detached home traditional landscapes at each of the four selected research sites.

5) Collection of metered water use information and other data that can be obtained without contacting the residents of the sample homes, thus avoiding the possibility of consumer bias (the so-called Hawthorne effect).

6) After metered water use information is obtained, conduct follow-up surveys and telephone interviews of sample homes for the purpose of obtaining information necessary to complete the data collection (occupancy levels, presence of water using features, etc.).

6) Analysis of data collected using rigorous statistical analysis techniques.

7) Preparation of final report.

## Final Product

A report documenting the research methods and findings in detail will be prepared. Overall implications obtained from the four sites will be addressed and presented. The report will include a slide show for each of the four research sites.

## Project Funding

The cost of this project is estimated at $35,000 per site for a total of $175,000. This estimate assumes that the study will be conducted by one research contractor. The estimate further assumes that data collection will be accomplished in large part by student trainees hired during the summer months.

## PROJECT TITLE: WATER SAVED BY WATER EFFICIENT TOILETS

### Project Background

As water supplied through conservation and demand side management (DSM) initiatives becomes a significant factor in Integrated Resource Planning and affects rate-base decisions and capital budgets, it is increasingly important to verify the reliability and duration of conservation efforts. The savings that have been documented on past programs are not applicable to long-range planning in other locations because they were site specific and measured only the short-term impacts of the program. In urban centers of large cities, multi-family housing offers geographical-density and substantial water conservation opportunities and is, potentially, the most cost-beneficial customer segment to target for study. In suburbs, the retrofit of single family homes represents the best target.

Research data on the savings from ultra low flush (ULF) toilets is limited. A recent study in Santa Monica and Los Angeles showed significant savings of about 20 percent of indoor residential use. Some of the savings from this program may have been due to the replacement of leaking toilets with non-leaking toilets. Separate estimates of the savings due to leak repair are not available and it is not known if the buildings studied had above average leakage rates. Data is needed from other areas of the country to develop information that can be used on a nationwide basis. This data will be useful in forecasting future water demand.

### Project Goals

To perform evaluations of residential toilet rebate/retrofit programs in order to document a range of verified and reliable savings. By studying similar programs in two or three different cities and utilizing the same data collection and analysis techniques, we could quantify (with a high level of confidence) the resulting water savings in any locality - regardless of local environmental factors. An ancillary objective would be to identify and quantify the impact of certain local, environmental factors on savings.

### Research Methodology

1) Programs evaluated as part of this study would target at least one city involving multi-family buildings and at least one city targeting single family homes for retrofit/replacement of toilets.

2) Two or more cities which were implementing similar programs would be evaluated over the same time period.

3) Participating dwelling units would be monitored over time to determine baseline,

pre-retrofit consumption and the existence of any factors which could impact post-retrofit results.

4) Leakage tests will be performed on each home or building in the sample to identify quantity of water leaking.

5) At the time of installation, occupants will be polled for water use habits.

6) Post-installation consumption will be monitored for several months after installation.

7) Difference in results due to local and/or site specific factors will be quantified.

**Final Product**

Reliable data to be used by water purveyors when evaluating the savings to be attained by implementing urban conservation toilet rebate/retrofit programs. Data will be separated into savings due to installation of ULF toilets and savings due to repair of leaks at the time of the retrofit.

**Project Funding**

The estimated cost of this study is $200,000.

No. 8

## PROJECT TITLE: INTEGRATING DROUGHT MANAGEMENT AND LONG TERM WATER CONSERVATION

**Project Background**

AWWARF is currently funding a project on the "Impacts of Water Use Reductions on Water Utilities." This project will research the link between water use reductions and the design and planning of capital facilities and utility operations. This project will extend that work into the area of sizing and operating facilities to deal with droughts at an accepted level of reliability and the impact of water conservation programs on future drought response activities.

A related need is to quantify the impacts of past droughts on customers to enable planners to establish a reasonable and acceptable level of planned short-term water use reductions. This information would enable planners to integrate the drought plan into decisions of if, when, and how big to build additional supply facilities and how to operate them.

## Project Goals

The goals of this project are:

1) Research cases of where capital facilities have been, or will be, designed to provide less than protection against the worst drought on record incorporating mandatory water use cut-backs in droughts.

2) Through case study research, identify which long-term conservation and short term drought measures contribute to demand reductions during drought, including the longevity of their impacts.

3) Provide guidance for water planners on how to integrate long-term conservation and short-term drought response into the sizing, timing, and operation of capital facilities to achieve acceptable reliability.

## Research Methodology

A number of utilities with interesting drought histories and capital facility planning experience will be solicited to participate. The utilities will provide the data base for the project. The research tasks are as follows:

1) Conduct literature review.

2) Research a representative nationwide sample of cases where water utilities have relied on a combination of physical facilities (reservoirs), long-term conservation, and short-term drought measures to meet needs during a drought, and document water use reductions and general customer impacts from mandatory measures.

3) Document cases where utilities are consciously sizing and operating water supply facilities in conjunction with long-term conservation, and short term measures.

4) Evaluate results and develop new procedures for integrating drought planning, long-term water conservation and water supply planning and management.

## Final Product

A report describing new water resource planning procedures for integrating drought response, long-term water conservation, and water supply planning and management.

## Project Funding

This project is estimated to cost $175,000.

No. 9

## PROJECT TITLE: PERFORMANCE STANDARDS FOR WATER EFFICIENT APPLIANCES

### Project Background

Under mandates from the federal government to develop market-driven, energy efficient technologies, energy utilities each developed relationships with manufacturers to build utility-designed prototypes of such futuristic technologies as electric and natural gas vehicles, geothermal heat pumps and super-efficient household appliances. Recently, the energy utilities implemented a more effective solution: from now on, the energy experts will stick with what they do best - specify product consumption efficiencies, and let the manufacturers do what they do best - design, produce and sell appliances. The "Golden Carrot" program rewarded the manufacturers with the best design for a market-ready, competitively priced, super-efficient refrigerator. The Canadian government has a program which allows manufacturers of appliances that meet specified environmental standards to advertise that conforming products have been approved. Similar cooperative approaches would be effective in developing the next generation of water-efficient appliances.

For example, highly efficient clothes washers account for less than two percent of all retail washing machines sales, yet command over a 90 percent market share in Europe. Estimated savings opportunities are large: 4,000 gallons a year for an "average" household for water and sewer, and 800 KWH of energy (or gas equivalent). Most of the energy savings comes from a greater reduction in remaining moisture content after spin cycles, and reduced dryer time.

Extension of the concept of "green refrigerators" to washers, refrigerators, garbage disposers, and other water-using appliances is an attractive option for financial partnership between energy, water, solid waste, and sewer utilities. From a customer viewpoint, savings in detergent, energy, and water and sewer are in the range of under a three year payback. With the potential for cost-effective rebates by combined utilities being close to the incremental cost of the machines, customers could be offered an efficient machine at about the same cost as an inefficient one, thus causing a rapid U.S. market transformation.

### Project Goals

The goals of this project are to identify residential and small commercial applications where water use could be significantly reduced with technological improvements and where an incentive to manufacturers would hasten the production of such efficient appliances.

### Research Methodology

1) Identify applications for improved appliance efficiency. Washing machines and dishwashers have been frequently suggested for this purpose.

2) Determine the level of stimulus needed as an inducement to design and produce the appliance.

3) Conduct a manufacturer and utility forum and establish a cooperative program with utilities and manufacturers to develop reasonable performance standards and to test market products.

**Final Product**

A Report identifying incentive strategies for improving water using appliance efficiency including ways and means to achieve wide consumer acceptance and use.

**Project Funding**

Initial research, manufacturers' forum, and draft performance standards would cost $100,000. Additional financial incentives could be provided in cooperation or partnership with selected manufacturers for selected appliances. Funding for this portion would have to be determined at a later date.

NO. 10

**PROJECT TITLE: EFFECTIVENESS OF PUBLIC INFORMATION THAT PROMOTES WATER CONSERVATION**

Project Background:

Water utilities sometimes spend considerable amounts of money on public education tools and materials (brochures, billboards, PSAs, etc.) to promote customer awareness about the importance of water conservation. The goals for this are twofold: (1) to promote customer awareness about conservation as well as utility concern for same and (2) to solicit customer participation in conservation program. Despite all the money, time, and resources expended for these efforts, there exist virtually no data that document whether such efforts result in actual water savings and benefits to utilities. Further, there is very little understanding of how different customer groups (by category and socio-economic characteristics) respond to conservation-oriented program marketing efforts. The only substantive work on the measurement of the impact of public information water conservation programs has been completed by the Metropolitan Water District of Southern California and the City of Phoenix. This research proposal would not only expand and refine that research, but would also result in the development of a handbook that leads to the establishment of effective conservation-oriented public education programs. The bottom line is that the water utility industry is currently investing in something for which it can show no definitive results or clear benefit.

## Project Goals

1) Determine the impacts of public education approaches on customers' knowledge, attitudes, and behaviors.

2) Identify the factors that influence and determine customer response to public education programs on water conservation.

3) Develop guidelines for utilities to design effective public education programs on water conservation that will promote customer participation. Identify variables to customer responsiveness by socio-economic characteristics and other relevant factors.

4) Develop guidelines for utilities to use in identifying effective public outreach strategies and tools that will result in customer participation in water conservation programs. Identify variables to customer responsiveness by socio-economic characteristics and other relevant factors.

## Research Methodology

1) Design a survey of customer responses to conservation-oriented public education.

2) Select an appropriate sample of utilities to use as a project "laboratory".

3) Correlate customer behavior with public education strategies and materials.

4) Analyze data.

5) Develop recommended industry guidelines.

6) Prepare final report.

## Final Product

Identification of key elements leading to effective public education strategies and tools that correlate with customer implementation of conservation measures; recommended guidelines for utilities to identify effective conservation-oriented public education and outreach strategies and tools; and final report of research findings and recommendations.

## Project Funding

Funding required is estimated at $150,000 - $200,000 and the time required for the study is 12 months.

## PROJECT TITLE: REGULATORY INCENTIVES TO PROMOTE WATER CONSERVATION

### Project Background

Current regulatory policy provides few incentives for water utilities to aggressively pursue water conservation. This is true of regulatory policies of environmental agencies at all levels of government (e.g., EPA, state water departments, state public utility commissions, and regional agencies).

Environmental agencies often hamper water utilities through administrative road blocks. They traditionally have relied upon "command and control" regulatory approaches to compel water utilities and others to adopt water conservation programs. While such approaches have led to the development of many new conservation programs, many are "bare bones" - often the minimum required.

Water utilities have argued that reliance on "command and control" approaches will not promote enhanced program development. Instead, they argue that environmental agencies should provide incentives to utilities to implement conservation. There is a need to answer two questions concerning this argument. What kinds of incentives can environmental agencies offer water utilities? Would these incentives induce utilities to conserve water?

Public utility commissions also have provided few incentives for utilities to implement water conservation programs. This is particularly true for financial incentives. The fact that profits increase with sales exacerbates the problem, particularly for the "privates" since many are owner by stockholders, a sizable percentage of which depend on the dividends paid. Sustained reductions in sales may not only hurt profits, but also impact a utility's status in credit markets.

Therefore a utility-sponsored conservation program may directly conflict with the financial interest of the utility and stockholder, although such a program may yield significant benefits to society. This suggests that regulatory policy makers should assess the financial incentives currently used by water utilities so that cost-effective conservation programs can be profitable to water utilities.

### Project Goals

The goals for this project would be to identify and examine mechanisms available to environmental agencies and state public utility commissions to promote enhanced water conservation program development and implementation. For environmental agencies, this research would accomplish the following:

1) Identify regulatory incentives to conserve water, including:

- "fast-tracking" new permits
- extending existing permits
- memorandums of understanding
- seminars and conferences
- "gold stars"
- regulatory relief during drought periods.

2) Determine acceptability of regulatory incentives according to various considerations, including:

- political
- legal and administrative
- economic and financial
- environmental

For state public utility commissions, the proposed research would examine the following:

1) Identify financial mechanisms currently used by state utility regulatory commissions to promote water conservation by water utilities.

2) Identify what shortcomings, if any, exist with financial incentives currently adopted by state utility regulatory commissions for water utilities through a comparison of incentives available to electric and water utilities.

3) Identify financial mechanisms currently used by state commissions to encourage utility water conservation by electric utilities.

4) Determine the applicability of financial incentives used to encourage water conservation among electric utilities to water utilities.

5) Develop model guidelines to improve financial incentives among water utilities.

**Research Methodology**

1) Literature review.

2) Water utility and regulatory agency surveys.

3) Interviews.

4) Model guidelines for financial incentives.

5) Report preparation.

**Final Product**

A report outlining alternative regulatory incentives for achieving water conservation.

**Project Funding**

This project is estimated to cost $125,000.

No. 12

## PROJECT TITLE: APPROPRIATE TECHNOLOGY FOR COOLING WATER USE

**Project Background**

Cooling water is the single largest water use in the non-residential customer base in North America. Significant volumes of water can be saved by improving cooling efficiency by increasing cycles of concentration and reducing bleed rates through various treatment options.

Major categories of treatment include chemical, acid, non-chemical, ozone, and other alternative treatments. The efficacy of these treatments will depend on parameters such as make-up quality water, temperature reduction of the recirculating water, cooling load, tower capacity, and other factors. Reclaimed water as viable make-up water in certain situations needs to be evaluated.

Non-residential customers and conservation professionals are frequently approached by vendors of alternative cooling treatment technologies. These technologies can include magnetics, ion sticks, catalytic metals, and many others. To date, there is no conclusive evidence that these technologies work, what their effects on cooling systems are, or what their useful life may be.

A great many improvements have been made in treatment technologies for cooling towers, but many users are very wary of "messing with their equipment" if it has been functioning satisfactorily. Conservation takes a back seat in proper facilities management. As a result, large volumes of water are wasted, as well as chemical treatment and energy costs. Wastewater charges are also higher as a result of poor cooling management.

There has been little investigation and analysis of recycling and reuse of different types of water for cooling tower use. However, there are several examples of reclaimed water use in cooling towers. The Irvine Ranch Water District requires new non- residential facilities to have dual-delivery water systems installed, as an example.

## Project Goals

1) Establish the parameters that affect cooling tower water treatment, such as make-up water quality, cooling load, cooling tower type and capacity, and the temperature differential before and after cooling.

2) Formulate recommendations an auditor can use to identify the most appropriate method of treatment given the various parameters.

3) Develop a list of alternative cooling treatments in use nationwide. Describe how each technology works. From case studies and reliable testimony, determine the effectiveness of each technology, its life, its ability to effect cost and water savings, and its viability.

4) Determine how much water can be saved by using ozone and the effect of ozone on equipment (corrosion, etc.).

5) When auditing cooling tower efficiency and formulating recommendations, the most appropriate method of treatment should be identified. A reference for making those recommendations would facilitate the water audit process.

6) Describe present examples of the use of reclaimed water in cooling towers. Investigate all the issues/benefits/costs/problems involved in the use of reclaimed water in cooling towers. Problems can include phosphorus, nitrogen nutrients, development of secondary delivery system and replumbing of facilities, microbial growth, increased TDS, increased potential of scale and corrosion, public health issues concerning drift from towers, whether a facility can reuse water without building an on-site softening plant, etc.

## Research Methodology

1) Identify the types of treatment and their variations, such as the various chemical treatment and filter systems that are available, with full descriptions of all treatment technologies. Identify the parameters that affect choices in cooling tower water treatment.

2) Develop list of standard and alternative cooling treatments, including ozone. Conduct literature and case study review and vendor information search. Report on conclusions of treatment cost, effectiveness, useful life, and effects on cooling systems. Develop list of recommendations of treatment for various cooling operation conditions.

3) Literature and case study review of ozone treatment of cooling towers. One full year of a side-by-side ozone treatment test.

4) Literature review of use of reclaimed water in cooling towers. Review of case studies, including costs. Develop list of public health concerns and how to deal with them.

## Final Product

The final product would be a report describing the research methodology, the parameters that affect cooling tower water treatment, and recommendations for each type of treatment. A matrix summarizing the findings would be useful to the auditor for easy reference.

Technical paper reviewing case studies, issues, costs, and how to deal with the potential problems resulting from the use of standard chemical, ozone, non-chemical and other alternative treatments, and reclaimed water in cooling towers. Report will include review and evaluation of side-by-side ozone treatment.

## Project Funding

A cooperative effort with the Cooling Tower Institute (CTI) or another industry organization could be arranged to reduce costs and use of staff time. CTI has a Water Treatment Committee, which might be an ideal information source. If prior research in this area is an adequate basis for recommendations, the research may consist of summarizing research findings in the report. Experts can also be found in organizations such as the National Association of Corrosion Engineers, International Association of Ozone Association, and the American Institute of Chemical Engineers.

Project funding needs are expected to run approximately $250,000. It is estimated that $100,000 of this amount, however, can be requested from the Cooling Tower Institute leaving $150,000 for AWWARF to fund.

No. 13

## PROJECT TITLE: WATER SAVED BY RETROFITTING NON-RESIDENTIAL REST ROOMS

## Project Background

While many utilities have had programs promoting efficient fixtures in residential homes, few programs for commercial retrofit of restrooms have been examined. Documentation on cost-effectiveness of retrofit of urinals, faucets, and commercial type toilets in these settings is limited but expected to be very high. This is a conservation strategy that can be done quickly by a utility on publicly owned buildings or in privately owned office buildings. By targeting high use fixtures (more than fifty uses per day per fixture) retrofitting would be very cost effective for both the owner and the utility. Recent work at Denver Airport suggests the need

to look at a number of high use situations such as office buildings, and other public rest rooms before large scale retrofit programs are targeted to this sector.

## Project Goals

The goals of this project are:

1) To test and evaluate the performance of water efficient toilets in different commercial settings and make recommendations about their use.

2) To evaluate the cost effectiveness of replacing toilets in public restrooms with more efficient units.

## Research Methodology

1) Select demonstration/test sites.

2) Set up instrumentation and monitoring plan.

3) Examine the performance of various types of gravity and pressure assisted 1.6 gpf fixtures in various commercial settings covering the spectrum of what is found in the field (stadium, small office, etc.).

4) Study and determine if there is a relationship between toilet location in the restroom and blockage incidence.

5) Compare water and energy savings vs any increase in service maintenance found for any of the settings.

## Final Product

A report documenting the performance and effectiveness of water efficient fixtures in public restroom settings including recommendations suited to the type of commercial site as appropriate.

## Project Funding

This study is estimated to cost $130,000.

## PROJECT TITLE: WATER SAVED BY NON-RESIDENTIAL WATER CONSERVING LANDSCAPES

### Project Background

Water conserving landscapes have been promoted in certain states by water utilities and certain members of the green industry for a number of years. However, little information has been developed on water use differences between water conserving landscapes and traditional landscapes in non-residential sectors. Preliminary studies indicate savings up to 40 percent of outdoor water use.

### Project Goals

The goals of this project are to:

1) Determine criteria defining water conserving landscapes versus traditional landscapes.

2) Make a statistically valid comparison of water used by water conserving and traditional landscapes in each of four communities located in four states, each having a different climate.

3) Develop a model which can be used to predict water use for water conserving landscapes versus traditional landscape for each of the four research areas.

### Research Methodology

1) Determine criteria defining non-residential water conserving landscapes and non-residential traditional landscape.

2) Separately meter non-irrigation and irrigation water use and determine variables that affect same. These shall include monthly water use determined by separate meter reads throughout the irrigation season; total irrigated area; area of turf; relative slope; relative shade; aesthetic evaluation of landscape; type of irrigation system including information on automatic controls; presence of exterior water using features or other extraordinary uses on irrigation system, i.e., pools, laundry rooms, cooling systems, etc.; and identification of leaks or extraordinary use during the metered water use periods.

3) Selection of a representative sample of sites with water conserving landscapes and traditional landscapes in each of the four selected research areas.

4) A file audit of each selected site to determine details on irrigation system, uniformity information, precipitation rate, design layout, type of soil, type of grass, root penetration, condition of system and repair of broken lines and heads.

5) Collection of information on fertilization, aeration, and chemical additives or treatment practices and other data obtained from previous studies or contractors responsible for maintaining the selected sites.

6) Analysis of data collected using rigorous statistical analysis techniques.

7) Preparation of final report.

**Final Product**

A report documenting the research methods and findings in detail will be prepared. Overall implications obtained from the four study areas will be addressed and presented. The report will include a slide show for each of the four study areas.

**Project Funding**

This project is estimated to cost $125,000.

No. 15

## PROJECT TITLE: SUB-SURFACE DRIP VS CONVENTIONAL IRRIGATION SYSTEMS

**Project Background**

Because turf irrigation is the single largest contributor to seasonal peak use, some hard data on irrigation methods would be valuable for water conservation planners. Such data would provide a foundation for design of more effective conservation strategies and programs and contribute to the accuracy of conservation projections in integrated resource planning processes.

Sub-surface drip irrigation (SDI) has long been haunted by the inability of product material to withstand root intrusion. Over the past several years at least two products have been developed and tested, however, which hold great promise in solving this problem and thereby making use of SDI potentially feasible on a broad scale for irrigation of small turf parcels. Small turf parcels are commonly found in single family detached home landscape settings, sidewalk medians, street medians and medians at commercial landscape sites. Surface irrigation of these sites is very inefficient and causes significantly higher secondary maintenance costs for adjacent asphalt surfaces and building walls. Successful application of SDI would greatly reduce, if not eliminate, these high secondary maintenance costs and would also achieve

significant water savings. Information on the effectiveness of SDI for irrigation of small turf parcels and resulting water savings is sorely absent in the literature,however.

## Project Goals

The goals of this project are to:

1) Determine applied water requirements and the relative efficiency of water use for lawn irrigation with sub-surface drip, automatic, manual, and hose sprinkler systems under normal use conditions and various sprinkler hardware.

2) Quantify water use for selected sprinkler hardware and systems, including sub-surface drip in several different soil and climate regions of North America.

3) Review the application of SDI on small turf parcels throughout North America and report on findings to date, particularly focussing on the traditional root intrusion problem.

4) Identify SDI products that have demonstrated general suitability for irrigation of small turf parcels, exhibit a reasonable pressure-flow relationship, have relatively small manufacturing variability, have demonstrated insensitivity to clogging, and are available at reasonable cost.

5) Determine recommended detailed design criteria for installation of SDI for small turf parcels.

6) Evaluate the cost-effectiveness of irrigation techniques for small turf parcels.

## Research Methodology

1) Perform literature survey.

2) Contact manufacturers and others, such as the California Center for Irrigation Technology, for reference information on SDI and installation design criteria.

3) Compile the information obtained in Steps 1 and 2 describing the present use of SDI for irrigation of small turf parcels and identify at least two products which meet the general product evaluation criteria for suitability, pressure-flow relationships, manufacturing variability, insensitivity to clogging, and availability at reasonable cost.

4) Define design criteria for small turf irrigation products.

5) Select products and representative study sites based on soils, climate, and other factors

for several regions of North America.

6) Determine the applied water required for SDI versus other systems using test site results and other research studies.

7) Compile and compare information on the cost to install and operate SDI and other systems for selected turf sites (street medians, shopping center medians, and single family detached home lawn sites). This cost comparison shall include a life cycle analysis and take into account expected water savings, and reduced secondary maintenance costs.

**Final Product**

A report documenting the literature survey and results, evaluation of cost effectiveness of using SDI and other systems on small turf parcels, and design criteria shall be prepared. Also a slide show shall be prepared which visually depicts the application of SDI and other technologies and sets forth the key findings of the research.

**Project Funding**

This research project is estimated to cost $125,000.

No. 16

## PROJECT TITLE: URBAN WATER CONSERVATION FINANCING MECHANISMS

**Project Background**

Water utilities are moving beyond the relatively simple and inexpensive "first tier" water conservation effort of providing education materials (tip sheets, brochures, plant lists, inexpensive leak detection, and retrofit kits, etc.) and into implementing more far-reaching programs (toilet rebates, irrigation audits, commercial audits, residential audits, utility-sponsored installation of water conservation devices, landscape rebates, shared savings programs, etc.). The rewards in the amount of water saved are much larger, but the costs are much greater.

A good example is the toilet rebate program being conducted by the Los Angeles Department of Water and Power (LADWP). In Phase I, LADWP offered rebates of $100 per toilet removed and replaced with one of the new ultra low flush (1.6 gallon per flush) toilets. Within 90 days, $23 million in rebates were paid out! The point is that second and third tier water conservation efforts require substantial funds. Many utilities cannot borrow money for these types of demand-side investments, even though comparisons may show they are more cost-effective than some supply-side options. Funding in many cases must come from current earnings or reserves. Some private utilities must provide funding for water conservation solely from net profits,

thereby reducing dividends paid to stockholders.

As water conservation investments grow, the ability of the utility to pay for same from current revenues, available surpluses, or net profits becomes more and more difficult if not impossible. Certainly it is unfair to existing rate payers and in the case of investor-owned utilities, stockholders. Furthermore, from a public policy point of view, cost effective demand-side management options should be as easy to finance as supply-side options.

One solution to this demand-side funding gap is to create opportunities for all water utilities to borrow funds to capitalize their water conservation programs. Shared saving programs being pioneered by a number of electric utilities and a few water utilities also need to be examined.

## Project Goals

It is the goal of this research project to identify:

1) Existing funding mechanisms that public and private utilities have available to them for financing water conservation programs. This should be done for each state.

2) Case examples of innovative solutions to raising funds for water conservation programs (such as Fare Cal, a joint powers authority recently created in California which has authority to sell revenue bonds on behalf of member public agencies for energy and water conservation programs).

3) Shared savings programs that have been undertaken by water utilities and, to the extent the approach is transferable, by energy utilities.

4) Feasible mechanisms for funding water conservation programs.

## Research Methodology

The methodology suggested for conducting this research is:

1) Contact local sections, key utilities, state agencies, and water utility associations as necessary to determine whether public utilities can borrow funds for water conservation programs and the borrowing mechanisms available. Determine from local public utility commissions (or their regulatory equivalent) whether private water utilities can borrow funds for water conservation and whether they can recover the cost of water conservation program investments in their rate base.

2) Survey the few shared saving programs being conducted by water utilities.

3) Survey the shared savings programs being conducted by energy utilities, evaluate strategies applicable for water utilities, and set forth specific hypothetical examples.

4) Survey states for innovative case example solutions to the demand management financing gap and report findings.

5) Suggest mechanisms for financing water conservation programs. Work progress will be guided by a technical advisory committee provided by AWWARF.

**Final Product**

A detailed report showing results of surveys, containing case examples and recommended financing mechanisms including existing financing mechanisms available in each state.

**Project Funding**

Project funding requirements are estimated to be $55,000. Time to complete the work once commissioned is estimated to be nine months.

No. 17

## PROJECT TITLE: IN-GROUND SYSTEMS VS IRRIGATION WITH HOSE AND SPRINKLER

**Project Background**

Opinions vary about whether people with in-ground sprinkler systems use more or less water than "hose draggers", and whether automatic systems are more efficient than manual ones. The issue is muddied by the nature of lawn irrigation which depends on a variety of human perceptions, attitudes, and behaviors as well on the sprinkling methods and mechanisms and their performance.

Because domestic lawn irrigation is the single largest contributor to seasonal peak use in most urban areas, hard data on lawn irrigation methods and practices would be very valuable for water resource planning. Such data would provide a foundation for design of more effective conservation strategies, particularly programs targeting lawn irrigation. It would also contribute to the accuracy of conservation projections utilized in integrated resource planning processes.

**Project Goals**

1) Determine relative water use for single family home lawn irrigation with automatic in-ground sprinkler systems, manually operated in-ground sprinkler systems and hose/sprinkler systems under normal use conditions.

2) Quantify the differences.

3) Identify factors which account for differences including equipment, attitudes and behaviors.

4) Identify regional differences in the findings, if any.

## Research Methodology

1) Review literature.

2) Define study regions representing a variety of climates and economic characteristics.

3) Select representative sample groups with manual in-ground sprinkler systems, automatic in-ground sprinkler systems and hose sprinkler systems.

4) Audit each site to assess irrigated lawn area, type of grass, precipitation rate and uniformity of system, soil type and profile, shade, exposure, and slope.

5) Collect daily weather data and calculate reference evapotranspiration (ET) and ET for grass (ETg).

6) Working with local water utilities, sub-meter outdoor water use and read meters at specified uniform intervals during a single irrigation season.

7) Conduct follow up surveys to clarify findings.

8) Compile and analyze data including calculation of irrigation efficiency in terms of applied water vs. theoretical water requirement determined by weather data (ETg - effective rainfall).

9) Report on results and develop recommendations for improving water use efficiency with each type of sprinkler system.

## Final Product

A report for water conservation managers documenting, in quantitative terms, the difference in water use of different methods of lawn irrigation, describing the human, regional and mechanical reasons for differences and recommending strategies for improving irrigation efficiency.

## Project Funding

It is estimated this research work will cost $200,000 and take about a year to complete.

No. 18

## PROJECT TITLE: METER SIZING FOR REDUCED FLOWS

(This project is recommended for consideration by AWWA's Water Meter Committee. Members of the Conservation Committee extend their willingness to work cooperatively with the Water Meter Committee in defining fixture water use values and designing field studies.)

### Project Background

The national acceptance of 1.6 gpf toilets, 2.5 gpm shower heads, and other low-flow fixtures and fittings has resulted in the development of design guides for water supply and drainage systems within buildings. A corresponding need exists for water meter sizing. Oversized meters fail to register low flows resulting in lost revenue and undetected leakage.

### Project Goals

1) Gather instantaneous flow rate data from several building classifications, including residential, light commercial, commercial, and public access facilities.

2) Correlate flow rate data with population, fixtures, or other appropriate parameters.

### Research Methodology

1) Gather and analyze existing information on peak flow in single family dwellings. Establish peak and average flow rate and the expected variation.

2) Plan and collect data from selected buildings to provide a statistically sound base to develop design flows.

3) Analyze the collected data to establish recommended meter sizes based on building size, use, population density, or other parameters such as fixture units.

4) Prepare a recommended practice for meter sizing (similar to the existing AWWA publication).

### Final Product

A report of findings supporting the recommended practice for meter sizing.

### Project Funding

It is estimated this work can be completed in one year at a cost of $120,000.

## APPENDIX B

## LIST OF 74 ORIGINALLY SUBMITTED RESEARCH PROJECTS
**(Including name of submitter)**

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**List of 74 Urban Water Conservation Research Needs Submitted for Consideration at the Workshop**

1 Conservation Pricing: Response of Nonresidential Water Users
Feather, Timothy; Planning and Management Consultants, Carbondale, Il
2 A Computerized Methodology for Estimating ICI Water Use
Gorden, Marsha; Mass. Water Resources Authority, MA
3 A Computerized Methodology for Estimating ICI Water Use
Ploeser, Jane; City of Phoenix, AZ
4 Advanced Conservation Techniques for the Electronics Industry
Ploeser, Jane; City of Phoenix, AZ
5 Alternative Cooling Treatments
Ploeser, Jane; City of Phoenix, AZ
6 Conservation Potential of Ozone Treatment for Cooling Towers
Ploeser, Jane; City of Phoenix, AZ
7 Cooling Tower Water Treatment Parameters
Ploeser, Jane; City of Phoenix, AZ
8 Flush Valve Toilet Retrofit
Ploeser, Jane; City of Phoenix, AZ
9 Saving Data from Existing ICI Programs
Ploeser, Jane; City of Phoenix, AZ
10 Survey of Air Cooled Equipment
Ploeser, Jane; City of Phoenix, AZ
11 Survey of Low-Cost Water Reuse Systems
Ploeser, Jane; City of Phoenix, AZ
12 Technology Investigations
Ploeser, Jane; City of Phoenix, AZ
13 Third Party/Shared Savings Program
Ploeser, Jane; City of Phoenix, AZ
14 Use of Reclaimed Water in Cooling Towers
Ploeser, Jane; City of Phoenix, AZ
15 Wastewater Recycling for Nonpotable Users
Ploeser, Jane; City of Phoenix, AZ
16 Effectiveness of Landscape Conservation Programs
Dietemann, Allan; Seattle Water Dept, WA
17 Sprinkler Hardware: Application Efficiency
Dietemann, Allan; Seattle Water Dept, WA
18 Documentation of Consumptive Water Use
Featherstone, Jeff; Delaware River Basin Commission, West Trenton, NJ
19 A Regional Guide to Water Demand of Trees, Shrubs, Perennials, Groundcovers and Grasses in North America
Inman, Elizabeth; Denver Water, CO

20 Efficient Home Lawn Irrigation: Sprinkler Systems vs Hose and Sprinkler Methods
Inman, Elizabeth; Denver Water, CO

21 Conserving Landscape Irrigation Water Use in the Northeast
Nechamen, William; NY State Dept of Environmental Conservation; Albany, NY

22 Effectiveness of Sub-Surface Drip Irrigation in Irrigating Small Turf Parcels Including Single Family Home Lawns
Nelson, John Olaf; North Marin Water District, CA

23 Evaluation of Water Saved by Single Family Home Xeriscapes
Nelson, John Olaf; North Marin Water District, CA

24 Documentation of Landscape Water Use
Prillwitz, Marsha; Calif Dept of Water Resources, Sacramento, CA

25 Low Cost Cisterns for New Residential Use
Robinson, Jim; University of Waterloo, Ontario, CANADA

26 Low Cost Cisterns for Existing Residential Use
Sharratt, Ken; Ontario Ministry of Natural Resources, CANADA

27 Potential Roles for GIS in Utility & City Managed Water Efficient Landscape Programming
Thurston, Anna; Tacoma Public Utilities, WA

28 Study of Customer Demand Characteristics to Enhance Forecasting of Conservation Rate Impacts
Amatetti, Edward; Wade Miller Associates, Arlington, VA

29 Demonstration Projects for On-site Water Reuse at Residential and Commercial Establishments
Anderson, Damann; Ayres Associates; Tampa, FL

30 Detailed Monitoring of Water Use Characteristics and Conservation Potential at Various Building Types/Locations
Anderson, Damann; Ayres Associates, Tampa, FL

31 Documenting Secondary Benefits from Conservation
Dietemann, Allan; Seattle Water Dept, WA

32 Financial Incentives: Customer Paybacks
Dietemann, Allan; Seattle Water Dept, WA

33 Regulatory Incentives to Promote Water Conservation
Featherstone, Jeff; Delaware River Basin Commission; West Trenton, NJ

34 A Guide to Managing Externalities in Integrated Water Resources Planning
Inman, Elizabeth; Denver Water, CO

35 Congruence of Indoor Household Water Use Patterns and Conservation Potential Between Communities
Inman, Elizabeth; Denver Water, CO

36 Evaluation of Energy Savings from Water Efficiency Programs
Jones, Andrew; Rocky Mountain Institute; Snowmass, CO

37 Evaluation of Water Savings from Efficiency Programs
Jones, Andrew; Rocky Mountain Institute; Snowmass, CO

38 Impact of ULF Fixtures on Wastewater Treatment Plants
Konen, Thomas; Stevens Institute of Technology; Hoboken, NJ

39 Integrating Drought Planning with Capital Project Decision Making
Maddaus, William; Montgomery Watson; Walnut Creek, CA
40 Integrated Resources Planning Guidebook
Minton, Jonas; Calif. Dept of Water Resources, Sacramento, CA
41 Adapting to the Impacts of Climate Change and Variability
Mortsch, Linda; Environment Canada; Burlington, Ontario, CANADA
42 Adjusting the Lead and Copper Mitigation Message to Minimize Excess Water Use
Nechamen, William; NY State Dept of Environmental Conservation; Albany, NY
43 Electric Utility Conservation Programs: Opportunities for Technology Transfer
Nechamen, William; NY State Dept of Environmental Conservation; Albany, NY
44 Incentives For Public Utility Commission To Encourage Water Conservation
Nechamen, William; NY State Dept of Environmental Conservation, Albany, NY
45 Managing Water Saved by Demand-Reduction Programs
Nechamen, William; NY State Dept of Environmental Conservation, Albany, NY
46 The Impact of Long-Term Conservation on the PlanningEnvironment of Growing Surface Water Systems
Nechamen, William; NY State Dept of Environmental Conservation, Albany, NY
47 The Impact of W.C. on the Operation and Efficiency of Wastewater Treatment Facilities in the N.E.
Nechamen, William; NY State Dept of Environmental Conservation, Albany, NY
48 Water Supply Infrastructure Improvement Funding Study To Achieve Long Term Water Conservation
Nechamen, William; NY State Dept of Environmental Conservation, Albany, NY
49 What are the Most Effective Ways to Reduce Residential Rate Uncollectables Through Water Conservation
Nechamen, William NY State Dept of Environmental Conservation, Albany, NY
50 Estimation of End Uses of Water
Opitz, Eva; Planning & Management Consultants; Carbondale, Il
51 Cooperative Energy/Water Programs
Ploeser, Jane; City of Phoenix, AZ
52 Interaction of Water Conservation and Industrial Pollution Prevention
Ploeser, Jane; City of Phoenix, AZ
53 Modelling Reductions in Water Use and Fiscal Requirements for Water Conservation Policy Instruments
Robinson, Jim; University of Waterloo; Ontario, CANADA
54 Evaluation of Residential End Use Water Demand
Rodrigo, Dan; Metro Water Dist., Los Angeles, CA
55 Impact of Price and Its Affect on Long-term Water Conservation
Rodrigo, Dan; Metro Water Dist., Los Angeles, CA
56 Development of New Design Methods for Building Planning System Design
Anderson, Damann; Ayres Associates, Tampa, FL
57 Performance Standards for 1.6 Gal Toilets
Anderson, Damann; Ayres Associates, Tampa, FL
58 Opportunities for Retrofit in Public Rest Rooms

Dietemann, Allan; Seattle Water Dept, WA

59 Tub Spout Diverters
Dietemann, Allan; Seattle Water Dept, WA

60 Water Efficient Washing Machine Research
Dietemann, Allan; Seattle Water Dept, WA

61 Design Data for Meter Selection and System Design
Konen, Thomas; Stevens Institute of Technology, Hoboken, NJ

62 Functional Performance and Transport Requirements for ULF Toilets
Konen, Thomas; Stevens Institute of Technology, Hoboken, NJ

63 Sub-Metering for Water Conservation
Konen, Thomas; Stevens Institute of Technology, Hoboken, NJ

64 Fire Hydrant Abuse - Locking Hydrant Caps and Water Demand
Liebold, Warren; NYC Dept of Environmental Protection, Corona, NY

65 Urban Low-Income Plumbing Repair Water Conservation Pilot Program
Liebold, Warren; NYC Dept of Environmental Protection, Corona, NY

66 Multi-Family Residential Impact Evaluation
Nadon, Barbara; NY State Dept of Environmental Conservation, Albany, NY

67 Stimulating Market Production of Water-Saving Appliances
Nadon, Barbara; NY State Dept of Environmental Conservation, Albany, NY

68 Self-Reporting Leaking Toilets
Robinson, Jim; University of Waterloo, Ontario, CANADA

69 Low-Cost Self-Reading Water Meters
Sharratt, Ken; Ontario Ministry of Natural Resources, CANADA

70 Pipe Sizing for Water-Efficient Residences and Residential Neighborhoods
Sharratt, Ken; Ontario Ministry of Natural Resources, CANADA

71 Water-Efficient Dishwashers
Sharratt, Ken; Ontario Ministry of Natural Resources, CANADA

72 Water Use by Household Plumbing Fixtures and Appliances in North America
Vickers, Amy; Vickers & Associates, Boston, MA

73 Proposed Study Plan for Commercial ULFT's
Interior Plumbing Subcommittee, Mary Ann Dickenson & Tom Pape

74 The Impact of Customer Attitude and Physical Variables on Water Use Before, During and After a Drought
Lynn Anderson-Rodriguez; Santa Barbara Co. Water Agency, Santa Barbara, CA.

In addition to the above contributors and workshop members, important ideas and contributions were also received from a special committee of water conservation experts from the northeastern United States led by William Nechamen, New York State of Environmental Conservation, Albany ,NY and from the following individuals:

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Many Thanks!

**- The End -**