

WILLIAM B. DeOREO, P.E.

TITLE:

President, and Principal Engineer, Aquacraft, Inc. Water Engineering and Management
2709 Pine Street, Boulder, CO 80302.

WORK EXPERIENCE:

President and Principal Engineer, Aquacraft, Inc. Water Engineering and Management 1990-present.

Principal Engineer, Co-Founder of Hydrosphere, Inc. (Formerly WBLA), Boulder, Colorado, 1985-1990

Water Resource Engineer Wright Water Engineers, Denver, Colorado, 1980-1985

Utility Project Coordinator, City of Boulder, Boulder, Colorado, 1978-1980

AFFILIATIONS:

American Society of Civil Engineers

American Water Works Association

Chi Epsilon, Tau Beta Pi. National Engineering Honor Societies

QUALIFICATIONS:

Mr. DeOreo has been actively practicing water engineering since 1978 after receiving his Master Degree in Civil and Environmental Engineering from the University of Colorado, Boulder. Prior to this he received a Bachelor of Arts (Biology) from Boston University, in 1971, and a Bachelor of Science (Civil Engineering) from University of Colorado, Boulder, in 1975. He has worked both in the public sector and as a private consultant. His main interests are in development of innovative supplies of water for municipal uses, improving the yield of urban water systems through better water planning and management, integration of urban water uses into watershed analyses, and development of computer based applications to assist with water planning.

Mr. DeOreo has testified as an expert witness in water court for Divisions 1 and 5. He has done water engineering for augmentation plans and changes of use cases. Please see the water rights and expert testimony section below for descriptions.

Some recent experience includes:

Water Systems Planning and Demand Forecasting

Water Rights Hydrology

Water Conservation Studies

Evaluation of impacts of retrofits on residential water demands

Quantification of penetration rates of high efficiency fixtures and appliances

Specialized Studies on Disaggregated Water Use and Demand Profiling

Mr. DeOreo has participated in urban drainage master planning projects, large water rights transfers and augmentation plans, raw water master plans and numerous water utility related projects such as leak detection, hydraulic modeling and rate studies. He has a broad understanding of the technical, environmental and economic issues involved with water resources in Colorado and the West. He has testified as an expert witness in Water Court.

Under his direction, Aquacraft, Inc. has concentrated it in the area urban water management, and has created several innovative approaches to providing a more rigorous basis for analysis of water use. These have included the Trace Wizard system for collection and disaggregation of water use data via analysis of flow traces obtained from the customer water meter and several versions of Aquacraft's Integrated Conservation Model (ICM), which analyzes the impacts of water conservation along with supply side projects in order to help determine how best to minimize annual operating costs for water utility operations.

Mr. DeOreo was primary author for a paper the received the best paper award for the Water Conservation Division in 2012 entitled Insights into Declined Water Demands. This paper summarize results from demand analyses going back to 1995 and how changes to technology have causes residential demands to drop, even in cases where there has been little or no active conservation efforts on the part of water agencies.

SELECTED PROJECTS:

Analysis of Impacts of Weather Based Irrigation Controllers on Water Use In Castaic Lake Water District

This report provided empirical information about the performance of WBICs for water conservation through an examination of actual water use for over 1000 WBIC sites in the Santa Clarita Valley of California. The report started from the monthly billed consumption provided by the agencies for the entire single family populations of the four major water providers in the area (Santa Clarita Water Division, Valencia Water Company, Newhall County Water District, and Los Angeles County Waterworks District #36). From this, the WBIC homes were identified from the billing data, and tables of weather-corrected outdoor water use for each of the WBIC sites and for a Control group were assembled. This allowed a pre-post and a side-by-side comparison of weather-corrected outdoor water use to be performed.

Residential End Uses of Water Study, Abu Dhabi (2014). The Regulation and Supervision Bureau of the Emirate of Abu Dhabi performed a study of the end uses of water in 150 single family homes in the Emirate. Aquacraft sub-contracted with Dornier Consulting GmbH to perform the end use analysis of flow trace data obtained from the homes during the period from June 2013 to December 2013. The data for this study were collected using wireless data loggers and transmitted to Aquacraft for analysis. Over 3 million water use events were identified in the traces and a database of water use was created and linked to survey data provided by Dornier. A statistical analysis of the results was prepared as well as models of the factors that affect the water use.

Update and Extension of the Residential End Uses of Water Study (2012). Mr. DeOreo is principal investigator for the Water Research Foundation update to the 1999 Residential End

Uses of Water Study. This is a multi-year study that involved collection of flow trace data from 9 water agencies in the United State and Canada, disaggregation of the water use in the homes and analysis of the indoor and outdoor end-uses. The project provided information on household water use and the factors that affect it across the country. The flow trace data collected as part of the study also shows the frequency of use and volumes per use for key end uses of water that can be used to establish efficiency benchmarks and determine the percentage of homes that meet or exceed these specifications for toilets, clothes washers, showers etc.

Analysis of Residential Water Use in Jordan (2011). This was a two part study involving a pilot/feasibility study of the use of data loggers on low-head roof tanks in Jordan for obtaining flow trace data. Based on the successful outcome of the pilot study a larger study of 95 homes was analyzed and a report on the end uses was prepared. This study provided end use data for household and per-capita water use for residential customers in Jordan, which has been used for planning purposes. A series of training workshops were also held for local water engineers in the use of the hardware and software needed to conduct future analyses independently.

Albuquerque Single Family Water Use and Retrofit Study (2011)

Prepared for the Albuquerque Bernalillo County Water Utility Authority, this study used data logging and flow trace analysis on a random sample of 240 single family homes to obtain precise measurements of indoor and outdoor water use, and to determine end-uses of water in the sample. This provided accurate information on the baseline consumption and efficiency levels of the homes for both indoor and outdoor uses. After the baseline analysis was complete a smaller sample of approximately 30 homes was retrofit with high efficiency fixtures and appliances and their post retrofit usage was analyzed. The results showed the impacts of retrofits in single family water use along with the impacts of several other factors. This study suggests that there is a potential for saving nearly 9000 AF/Yr in the single family homes in the service area, mostly from the top quartile of water users.

California Single Family Water Use Study (2011)

This was a five year study of water use patterns in 10 large municipal water providers located in both Northern and Southern California. Mr. DeOreo was principal investigator on the project. The study used a combination of billing analysis, surveys, data logging/site visits and GIS analyses on a sample of over 730 homes, to obtain an updated snapshot of water use patterns and changes in efficiencies in single family customers throughout the State of California. Results were published in 2011. The study results included detailed statistics on end uses of water in the pooled sample. Mathematical models of water use were prepared that showed what factors affect single family water use the relationship between these factors and household water use. On a statewide level the study showed potential potable water savings ranging from a low of 27% of baseline use to a high of 50%, or 1.2 to 2.2 million acre feet per year from just the single family category.

Analysis of Water Use in New Single Family Homes (2011)

This study, funded by the U.S. concentrated on the analysis of end uses of water, and efficiencies of use, in new homes, built after January 1, 2001. Data were collected both on “standard” new homes and “high efficiency” new homes. An extensive set of customers surveys were first sent to random samples of residents in each of the study homes, which provided a good basis for later modeling of the data. Samples of new homes were visited and data loggers were used to obtain

flow traces, which were disaggregated into end-uses. A set of homes built specifically to be high efficiency, employing Water Sense standard devices plus high efficiency clothes washer, were also studied. The study highlighted progress in water use efficiency in newer homes, and showed that high efficiency new homes are capable of achieving very high levels of efficiency, with indoor use dropping to down to under 110 gallons per household per day, compared to 187 gphd measured in the 1999 REUWS study. Outdoor use was not as clear cut, but similar patterns were found in the factors that affect outdoor use.

Evaluation of Effectiveness of Water Budgets in San Diego County (2011)

This report evaluated the financial and water savings performance of a pilot program of landscape water targets in the Rincon Del Diablo Water District in San Diego County. The evaluation was based on pre-post, time series, analyses for 249 customers who were part of the program. Even though there was a strong general decline in overall water use in the County due to drought restrictions we were still able to identify savings of approximately 5% that could be attributed to the water target program.

California Institute for Energy and the Environment: Demand Profile Study (2009-2010)

As part of its update of its water and energy model, the CIEE needed to obtain new information on hourly water use patterns in the full range of water customers throughout the state. They contracted with Aquacraft to get this done. The project involved both mining of existing data plus obtaining new data on a series of single family residential, multi-family residential, commercial, institutional and industrial water customers in California. The objective of the study was to determine hourly patterns of use as part for the customers so that these patterns could be used in the energy demand model. The hourly demands were analyzed to determine the extent to which variation in customer demand resulted in variations in electric use by the water treatment plants, especially during peak energy demand period, when much higher electric rates were imposed by the electric utilities.

Single Family Water Use Update, City of Phoenix (2009)

In order to determine how water use patterns have changed in their single family residential customers the City of Phoenix and consultants Hazen and Sawyer retained Aquacraft to obtain updated end use data on the same 100 homes that were logged as part of the REUWS project. This report identifies changes in household use that have occurred between 1997 and 2009 in terms of gallons per household per day for each end use and the percentage of homes with high efficiency fixtures and appliances.

Cal PUC Water Conservation Evaluation (2009)

Aquacraft performed evaluations on the impacts of three water conservation programs for the California Public Utilities Commission. These were: an evaluation of the impact of weather based irrigation controllers on irrigation water use, an evaluation of the impact of pH controllers on cooling water use, and an evaluation of the impact of high efficiency toilet retrofits in low income multi-family households.

IRWD Multi-family Housing Water Study (2007-2008)

Using a combination of billing data and surveys Aquacraft evaluated the water use patterns in the multi-family customers in the Irvine Ranch Water District. Due to the high number of individually metered multi-family accounts in Irvine it was possible to do regression analyses on

the annual and seasonal water use for a large selection of customers by linking their consumption to results of surveys mailed to the customers. This study focused on evaluation of the factors that affect water use in multi-family residences.

EPA New Home Water Use Study (2006-2010)

This was a nationwide study of water use patterns in new single family homes funded by the U.S. EPA and 8 water agencies: Tampa and Jacksonville, FL; Phoenix, AZ; Eugene, OR; Roseville, CA; Salt Lake City, UT; Denver and Aurora, Co, Southern Nevada Water Authority (Las Vegas, NV). Using the data logger/survey approach the water use in these new homes was analyzed in detail to determine the factors that affect water use in new homes. In addition a group of high efficiency homes were built in order to demonstrate the impacts of use of best available technology in new home construction.

Evaluation of Restaurant Water Conservation (2005)

A data logging and metering system was used to quantify the impacts of high efficiency pre-rinse sprayers in a group of restaurants in the Santa Cruz/Monterey area. Both pre and post data were collected. Data were normalized against dishwasher use. This study is a good example of an evaluation study that uses high tech metering and data logging to quantify the impacts of a relatively small change to the water use regime of a restaurant. By collecting end-use data on the feed lines to the sprayers, along with data on the operation of the dish washers we were able to isolate the water use for pre-rinse sprayers and normalize it to dishwasher use. This allowed reliable information to be collected. Without this approach (i.e. if just the main metered water use had been used) the impacts of the sprayers would have been lost in the noise of the other uses (including leakage) at these establishments.

Evaluation of Drought on Residential Water Demands (2005)

The Denver Water department wanted to determine the reasons for the observed reductions in their single family residential water use following the drought of 2002. Aquacraft helped address this problem by returning to the homes that were logged in 1998 for REUWS. Each home was logged for 2, two week periods and the water use was disaggregated. Comparisons in the household and per-capita water use were performed to determine how the customers were reducing their water use.

Analysis of impacts of high efficiency devices on single family water demands (2005)

Aquacraft performed monitoring of indoor and outdoor water use at a series of single family homes being tested as part of the Environments for Living program by Masco. Indoor measures included high efficiency toilets, showers, clothes washers, hot water priming systems and faucets. Outdoor measures included low water use landscape designs and smart irrigation controllers. This report dealt with the problems and opportunities involved with attempting to provide water efficiency “guarantee” to homebuyers.

Evaluation of CII Water Use, Sacramento (2005-2006)

Aquacraft conducted a series of on-site water efficiency reviews at approximately 50 CII customers in the Sacramento Regional Water Authority service area. Each review identified potential water savings at the sites and estimated costs and benefits for performing the water conservation measures identified in the reports.

Analysis of Factors that Affect Water Demands in Large Multi-family Properties (2004)

This was a study of water demands in a large sample of multi-family properties in over a dozen water agency service areas in the United States. The goal of the study was to determine how a range of factors affect water use per unit in the study group of multi-family projects. A combination of surveys, billing analyses and on-site audits were used to collect data. The primary area of interest was whether the presence of sub-metering as opposed to other water billing methods (ratio billing, in-rent billing, hybrid billing) was an effective water conservation measure (it was.) This study demonstrated that all else being equal the only billing method that creates a conservation effect is direct sub-metering and individual billing. A range of other variables were also evaluated in this study.

Analysis of Penetration Rates of High Efficiency Fixtures and Appliance, Seattle (2004)

In order to determine the natural penetration rates of high efficiency fixtures and appliances by its customers the Seattle Water Department hired Aquacraft to perform an analysis of 100 single family residences chosen at random from its billing database. These homes were data logged and their water use was disaggregated. The percentages of homes with ULF toilets (flushes less than 1.6 gpf), high efficiency showerhead (flow rates less than 2.5 gpm), and clothes washers (less than 30 gal/load) were determined. These were compared to the results obtained when Seattle participated in the REUWS in 1998. The changes in percentages over time were used to quantify the nature penetration rates of these devices over time.

Water Conservation in Urban Supermarkets, (2001-2003)

Urban supermarkets are major water users, especially their cooling equipment for refrigeration. This study examines use of various water treatment systems on the coolers to reduce water used for bleed, and use of high efficiency plumbing fixtures and faucet controllers in the rest of the store to reduce water use.

Tampa Retrofit Project, (2002-2003)

This is the third part of the study of the impacts of high efficiency fixtures and plumbing devices on residential water demands in combination with the studies in Seattle and East Bay. This study will build upon the results of the other two studies by using fixtures and appliances which exceed the efficiencies of those used there. As a whole, the three studies will give a very accurate picture of the saving potential from interior retrofits in typical American homes.

Colorado Department of Human Services Water Rights Study (2003)

The Department of Human Services has been charged with achieving a 20% reduction of all utilities in the current fiscal year. Aquacraft is working in association with Long Energy to determine the water rights available to DHS and the most efficient use and distribution of their water resources.

Prospect Ridge Best Available Technology Study (2002)

Aquacraft developed a water use model for the Prospect Ridge development in the Town of Bennett, Colorado. The model shows the reduction in water use that can be achieved through the use of best available technologies for water conservation in domestic and landscaping water management.

Pinellas County Utilities Water Conservation Opportunities Study, (2002)

Pinellas County Utilities, located just west of Tampa, Florida, has an active water conservation and alternative supplies program. They came to Aquacraft and asked, “where can we go from here to save water?” This study measured water use in samples of single-family and multi-family homes and made recommendations for future water conservation programs that could achieve the most savings in this specific community.

National Multiple Family Submetering and Allocation Billing Program Study, (2002-2003)

Charging residents in multi-family house separately for water is growing trend in the United States. This study looks at the entire phenomena of submetering and allocation billing techniques examining the potential water savings, regulatory issues, utility concerns, water rates, and regulatory climate.

Water Conservation Plan for City of Bozeman, Mt., (2001)

The City of Bozeman is situated in Gallatin Valley of Montana at the headwaters of the Missouri River. Growth rates are high and the citizens place a very high value on the quality of their environment. Mr. DeOreo developed an integrated water demand/financial model that showed the impacts of various water conservation options on the both water demands, capital spending and system finances. This model allowed the town to assess the potential of water conservation to delay several water treatment and storage projects.

Irrigation Demand Analysis, East Cherry Creek (2001-2002)

This water district has a raw water irrigation system capable of delivering a specific amount of water within both annual and instantaneous pumping rates. In addition, the system has storage capable of regulating demands. What was not known was the actual demands that would be placed on the system as irrigation customers were added. To answer this Aquacraft collected real time demand data from a large sample of the potential customers during peak demand times, and determined the relationship between irrigated area and hourly and instantaneous demands. This provided reliable estimates of demands for sizing the system.

East Bay MUD Conservation Retrofit Study, (2001-02)

This water efficiency retrofit study will measure the impact of high performance plumbing fixtures in 35 single-family homes in the Oakland California metropolitan area. Each home in the study will be fully retrofit with ULF toilets, conserving clothes washers, LF showerheads, and LF faucet fixtures. Aquacraft will collect flow trace data from each home before and after the retrofits so that the impacts of each fixture class can be measured and the cost-effectiveness evaluated. This study is funded by the US Environmental Protection Agency and EBMUD.

CII Demand Assessment and Conservation Plan, Westminster, CO, (2000-01)

The City of Westminster, a suburb of Denver has experienced substantial growth in the commercial, industrial, and irrigation sectors. Aquacraft evaluated trends in water use for this sector using available billing data and information from the local tax assessor and then developed a detailed water conservation plan targeted at these customers. Ten site audits were conducted to assess the conservation potential of individual customers. The final report is in the review process.

Seattle Home Water Conservation Study, Seattle Public Utilities and EPA, (1999-2000)

This water efficiency retrofit study measured the impact of high performance plumbing fixtures in 37 single-family homes in Seattle. Each home in the study was fully retrofit with ULF toilets, horizontal axis clothes washers, LF showerheads, and LF faucet fixtures. Aquacraft collected flow trace data from each home before and after the retrofits and the impacts of each fixture class were measured and the cost-effectiveness evaluated. This study is being used to promote the most promising water efficiency measures and products and to weed out measures that are not cost-effective.

Commercial and Institutional End Uses of Water, AWWARE, (1998-2000)

This study evaluated water use among commercial and institutional end uses of water in five cities. This study provided information on the most significant commercial and institutional customers in typical municipal water systems and the purposes for which these customers use water. Aquacraft was the prime contractor for this project. Our role in this study, beyond project management, was to conduct direct measurement field studies of CI demand and to assemble and edit the final report. We performed detailed water audits in 24 sites ranging in size from small restaurants to large high school campuses and implemented a variety of water use measurement programs to determine where water is used in these settings. The final report is available for purchase from AWWA.

Demand Analysis for the University of Colorado, (2000)

Aquacraft has conducted detailed demand analysis on two sites at the University of Colorado – The Mountain Research Station and the Cristol Chemistry Building. The Mountain Research Station is an alpine research facility with over 40 buildings including biology labs, dormitories, dining facilities, cabins, etc. Aquacraft performed a detailed audit of the site and prepared a disaggregated water budget and conservation plan. The Cristol Chemistry Building is one of the largest chemistry labs on the University Campus. Aquacraft collected flow trace data from this site and prepared a demand analysis report.

Residential End Uses of Water Study, AWWARE, (1996-1999)

In this four year project, funded in combination by the American Water Works Association Research Foundation and 14 cities across the US and Canada, disaggregated water use data were obtained from nearly 1200 single family residences. In addition to characterizing water use in the single-family sector, these data were used to develop a model of residential water use based on the demographic characteristics of the households and the specific water using fixtures and appliances present. The project was completed on schedule and on budget. The final report is available for purchase from the AWWA bookstore.

The database developed for this study is also available for purchase. The database includes a table of over 1.9 million individual water use events that have been analyzed according to end use, volume, start time, flow rate, and duration. These were obtained from scientifically selected samples from the single-family residential customers in each city. The database also includes a table of daily use for each household and extensive survey information that provides information on physical and demographic characteristics. When combined with weather information (for ET) this system provides a powerful tool for water supply and water conservation planning.

The participating cities and agencies in this study were: Boulder, CO.; Denver, CO.; Eugene, OR.; Seattle, WA.; Metropolitan Water District of Southern California; San Diego, CA; Walnut

Valley Water District, CA; Las Virgenes Municipal Water District, CA; Lompoc, CA.; Tampa, FL.; Phoenix, AZ.; Scottsdale, AZ; Tempe, AZ; Waterloo, Ontario; and Cambridge, Ontario.

Water Conservation Plan, City of Thornton, CO, (1998-2000)

The City of Thornton is faced with one of the highest growth rates in Colorado and an expensive new water supply. The impacts of water conservation on their system could be dramatic. Aquacraft, in conjunction with HDR consultants completed a water conservation plan for Thornton to determine the impact of a range of conservation measures on the City's water supply. Efficiency measures in the residential, CII, and landscape sectors were evaluated using Aquacraft's integrated conservation model. All conservation measures were compared to the City's structural alternatives in terms of yield and cost.

Comparison of Demand Patterns among CI and SF Customers, Westminster, (1997-1998)

Westminster, Colorado is a growing community in the Denver metropolitan area. The city is working on the development of a cost of service based rate system. In order to assist with this effort Aquacraft has collected flow trace data on a series of single family, multi-family, irrigation, and commercial accounts during peak demand period for the City. These data have been used to develop daily and hourly peaking factors for each category and a set of normalized demand parameters for use in projecting demands in future customers.

Water Conservation Futures Study, City of Boulder, CO, (1998-1999)

The City of Boulder is fortunate to have an abundant supply of high quality water, and they do not project any shortages in water supply between current conditions and build out. Nonetheless, the City recognizes that there are demand management issues to address both from the perspective of equity in the billing system and in the need to identify other potential uses for its water resources (such as in-stream flow maintenance). Aquacraft was part of the team hired by the City to conduct an analysis of the future of water conservation in all sectors in Boulder.

Water Efficiency in Water Wise and Standard New Homes, (1999-2000)

Aquacraft is conducting a study in Westminster Colorado to determine how water use in specially designed "Water Wise" homes compares with other new homes built at the same time. This project will measure the impact of the 1993 Federal plumbing codes compared to homes equipped with advanced efficient plumbing fixtures including conserving clothes washers and re-circulating hot water systems. Aquacraft's flow trace analysis technique was used to measure end uses in each of the 40 participating study homes.

Tucson Older ULF Toilet Study, (1998-1999)

Aquacraft is providing hardware, software, and technical support for a project that will evaluate the performance of ULF toilets that were placed into service in the early 1990s. It is suspected that these fixtures no longer operate at a flush volume of 1.6 gallons, thus potentially reversing conservation savings.

Analysis of Southern Nevada Xeriscape Project, (1998-2000)

Aquacraft performed a detailed evaluation of a Xeriscape conversion program in Las Vegas. 50 accounts that participated in the program are compared with 50 turf accounts that did not. Flow trace analysis techniques were used to separate indoor and outdoor consumption in the 100 study houses. Significant savings were found among Xeriscape homes. Report is available from

Aquacraft.

High Water Use Analysis, WSV Ltd. (1998)

The WSV Partners own several multifamily housing communities in the United States. Two of them, Sunset Ridge and Northgate in Denver appeared to be using excessive amounts of water. Aquacraft performed water use analyses of both complexes and using flow trace analysis quantified the indoor, outdoor use and leakage. Both projects were found to have significant leakage, and specific strategies were developed for repair of existing leaks and for identification of future leaks as soon as they exceed tolerable levels.

Westminster, Peak Use Study, (1996)

As part of its water planning process, the City of Westminster needed information on daily and hourly peaking factors for its major classes of customers. Aquacraft conducted a baseline study of peak use in single family, multifamily, irrigation, and commercial/industrial customers for the City. This study generated peak use factors as ratios to average day demands and in terms of gallons per day per unit.

Centennial Valley Water GIS, (1996-1997)

In order to determine the amount of wastewater being generated from an area of mixed development in Louisville, CO., Aquacraft developed a geographical information system which linked water billing and mapping information, thus allowing determinations to be made on deliveries of treated water to areas tributary to any specified portion of the sanitary sewer system. This system showed in which areas large discrepancies existed between measured wastewater flows and treated water deliveries and identified areas of probable I&I into the sanitary sewer system.

Westminster Residential Water Use Study, (1995-1996)

Using Aquacraft's flow trace analysis capabilities, 60 single family residential customers, divided into three distinct age groups, were sampled. The data traces from the meters were disaggregated into end uses so that the variations in water use in homes of different ages could be investigated. A primary goal of the study was to determine whether new homes, built to exceed the 1991 Energy Policy Act standards used less water per unit than other homes in the system.

Heatherwood Retrofit Study (1995)

Using the baseline data collected in 1994 as the starting point 14 out of the 16 homes in the Heatherwood study group were retrofit with high efficiency toilets, showers, and faucets. Four of the homes received horizontal axis clothes washers. Three weeks of end use data were collected and disaggregated and then compared against the pre-retrofit data in order to quantify the precise impacts of the retrofit on the individual water use category.

Heatherwood End-Use Study, (1994)

This project involved development of a pilot scale customer information system using a GIS. This PC based system uses AutoCAD tools to integrate existing City mapping with water use and lot specific information databases. Another important aspect of this project was the use of data loggers to acquire consumption profiles from a select study group (chosen using the CIS

system), which were then disaggregated into their individual components through signal processing techniques. This information provided accurate determination of percent of water devoted to individual purposes in single family residential customers. The effectiveness of soil moisture sensors for irrigation scheduling on automatic sprinkler system was also investigated.

MCDB Water Use Study, (1994)

The University of Colorado faced a wastewater Plant Investment Fee of \$219,000 for an expansion to the Molecular Cellular and Developmental Biology building on the Boulder Campus. A detailed study and water audit of the water and wastewater flow patterns and waste loadings was conducted which determined that the appropriate charges would be \$52,000, a savings of \$167,000.

Colorado Water Conservation Model, (1992-1993)

In order to implement the 1991 Water Conservation Act, the State of Colorado authorized the development of an integrated water system operations and economic model (CIRCE) which will allow system managers to assess both the hydrologic and financial consequences of alternative water management strategies. This allows an objective assessment of the relative benefits of both structural (supply side) and non-structural (demand side) projects.

WATER RIGHTS AND EXPERT TESTIMONY

Leistikow Reservoir Condemnation (2008) Mr. DeOreo testified as an expert witness in Boulder County District Court regarding potential uses for raw water storage in the South Boulder Creek watershed as part of either a municipal or industrial water supply.

Burnison Ditch Evaluation (1980, 1986) Evaluated irrigation system and historic consumptive use for Burnison and Burnison #2 ditches on Beard Creek in Water Division 5. Reviewed augmentation plan for Scottsville subdivision.

City of Northglenn Water Management Plan, 1982. Performed operations study of Northglenn's water supply and FRICO exchange. Provided expert testimony in Division 1 Water Court.

Clayton Hill Water Rights Evaluation. (1985) Performed evaluation of historic consumptive use of Clayton Hill ranch on Blue River near Green Mountain Reservoir. Provided water engineering for transfer of these rights to Town of Breckenridge, Goose Pasture Tarn. Expert testimony in Water Division 5

Silver Creek Ski Area Augmentation Plan. (1986) Transfer of agricultural water rights to snow making for Silver Creek Ski Area. Obtained first decree which allowed snowmaker to claim credits for return flows. Testified as expert witness in Water Division 5.

Gary Hill Ranch water rights evaluation on Muddy Creek. Quantified historic consumptive use of water rights of Hill Ranch on Muddy Creek. Obtained decree for use of these rights for alternate uses in Colorado River basin.

Kelly Ranch, Arkansas River. Analyzed historic consumptive use of Cottonwood Maxwell

Ditch for the Kelly Ranch near Buena Vista as part of purchase agreement. (1987)

Hill Ranch evaluation, Nathrop. (1988) Analyzed historic consumptive use of the Hill Ranch in the Arkansas drainage near Nathrop for purchase of rights.

Depletion Study on Anderson, Farmers, McCarty, Smith and Goss and Harden Ditches (1987) Performed analysis of historic consumptive use and depletions of water rights owned by City of Boulder for exchange to storage and minimum streamflow.

Bullhead Gulch water rights evaluation. (1991) Provided analysis of historic consumptive use and diversion system for senior water rights on Bullhead Gulch in Boulder County. Provided expert testimony for adjudication of rights in Water Division 1.

EDUCATION:

Master of Science, Civil/Environmental Engineering, University of Colorado, 1978

Bachelor of Science, Civil Engineering, University of Colorado, 1975

Bachelor of Arts, Biology, Boston University, 1971

Continuing Education.

"AutoCAD Data Extension Workshop" Wittreich and Associates, June 1994.

"GIS for Civil Engineering", GIS World, Fort Collins Colorado, April 1994

"C Programming," University of Colorado Continuing Education, June 1992

"Computer Applications for the Water Works Industry," AWWA Conference and technical training session on computer applications with concentration in use and calibration of current network models, April 1992

"Colorado Water Engineering Conference," Colorado State University and Colorado State Engineer, Denver, Colorado, February 27-28, 1990

"Water Marketing, Moving from Theory to Practice," The Institute for Advanced Legal Studies, University of Denver College of Law, November 15-16, 1990

"Moving the West's Water to New Uses: Winners and Losers," Natural Resources Law Center, University of Colorado School of law, June 6-8, 1990

"Colorado in the Wake of the Two Forks Decision," University of Denver College of Law, November 17, 1989

PUBLICATIONS:

DeOreo, William B., Mayer. Peter W. *Insights Into Declining Single Family Residential Water Demands*. . American Water Works Association Journal, June 2012 (This was given the best paper award by AWWA in the water conservation division for 2013)

DeOreo, William B., Mayer Peter W. *Improving Urban Irrigation Efficiency Using Weather Based "Smart" Controllers*, American Water Works Association (Best Paper Award, 2010)

DeOreo, William B., Mayer, Peter W., Chesnutt, Thomas, Summers, Lyle. *Water Budgets and Rate Structures: Innovative Management Tools*, American Water Works Association (Best Paper Award, 2008)

DeOreo, William B. *The Role of Water Conservation in a Long-Range Drought Plan*. American Water Works Association Journal, February, 2006

DeOreo, William B., Mayer, Peter W. *Third Party Billing of Multifamily Customers Presents New Challenges to Water Providers*, American Water Works Association (Best paper award for 2006).

DeOreo, William B. *The Role of Water Conservation in a Long-Range Drought Plan*. American Water Works Association Journal, February, 2006

DeOreo, W.D., Mayer, P.W. and Hixson, R. *Conservation in Paradise—How Water Conservation Works for the City of Bozeman Montana*. Proceedings of American Water Works Association Annual Conference, New Orleans, LA 2002

Mayer, P.W., DeOreo, W.B. and Kaunisto, R., *Raw Water Irrigation – System Sizing Poses an Interesting Problem*, Proceedings of American Water Works Association Annual Conference, New Orleans, LA 2002

Qualls R.J., Scott, J.M., DeOreo, W.B. *Soil Moisture Sensors for Urban Landscape Irrigation: Effectiveness and Reliability*. American Water Resources Association Journal, June 2001

W.B. DeOreo, A. Dietemann, T. Skeel, P. Mayer, et. al. 2001. *Retrofit Realities*. Journal American Water Works Association, March 2001.

W.B. DeOreo, P.W. Mayer, J. Rosales, et. al. 2000. Impacts of Xeriscape on Single Family Residential Water Use. Proceedings of Fourth Decennial National Irrigation Symposium, Phoenix, AZ.

P.W. Mayer, W.B. DeOreo, et. al. 1999. *Residential End Uses of Water*. American Water Works Association Research Foundation, Denver, Colorado.

W.B. DeOreo and P.W. Mayer, “Conservation Potential in Outdoor Residential Water Use.” Proceedings of Conserv99, Monterey, CA, 1999.

W.B. DeOreo, P.W. Lander, R. J. Qualls, J.M. Scott, “Soil Moisture Sensors: Are They a Neglected Tool?” AWWA Annual Conference Proceedings, Dallas, 1998

D. M. Lewis, W.B. DeOreo, K. DiNatale, “Case Study: Flow Trace Analysis to Determine Irrigation Efficiency in a Large Municipal Water User.” AWWA Annual Conference Proceedings, Dallas, 1998.

P.W. Mayer, W.B. DeOreo, E.W. Opitz, J. O. Nelson, “Residential End Uses of Water: Project Update, Year Two.” AWWA Annual Conference Proceedings, Dallas, TX.

W.B. DeOreo, DiNatale, K., "The Incorporation of End Use Water Data in Municipal Water Planning." AWWA Annual Conference Proceedings, Atlanta, 1997

P.W. Mayer., DeOreo, W.B., Opitz E.O., Nelson, J.O., "North American Residential End Use Study: Progress Report". AWWA Annual Conference Proceedings, Atlanta, 1997

W.B. DeOreo, Mayer, P.W., Lander, P., "Evaluating Conservation Retrofit Effectiveness with Precise End Use Data" AWWA Annual Conference Proceedings, Toronto, 1996

W. B. DeOreo, Heaney, J.P., Mayer, P.W., "Disaggregating Residential Water Use Through Flow Trace Analysis." Journal American Water Works Association, January 1996.

W.B. DeOreo, Lander, P., Mayer, P.W. "New Approaches in Assessing Water Conservation Effectiveness." AWWA Conserve '96 Proceedings

P.W. Mayer, Heaney, W.B., DeOreo, W.B., "Conservation Retrofit Effectiveness: A Risk-Based Model Using Precise End Use Data." AWWA Conserve '96 Proceedings

C.J. Iadarola, DeOreo, W. B., DiNatale, K., Zoellner, M., "Water Demand Management in Multi-Family Housing-The Role of Economics." AWWA Conserve'96 Proceedings

W.B. DeOreo, Lander, P., " Hard Data on Soil Moisture Sensor Performance: Summary of Soil Moisture Sensor Operations in Boulder, Colorado." Irrigation Association national meeting, Phoenix, AZ 1995

P.W. Mayer, DeOreo, W.B., "A Process Approach for Measuring Residential Water Use and Assessing Conservation Effectiveness." AWWA Annual Conference, Anaheim, 1995.

W. B. DeOreo, P. Lander, J, "Use of Soil Moisture Sensors to Automate Irrigation Scheduling in Existing Clock Driven Irrigation Systems", American Society of Landscape Engineers, 1994, Summer Meeting, Kansas City, MO.

W. B. DeOreo, Boand S., and Iadarola, C., "The Colorado Water Management Model: An Integrated Decision-Support System for Water Conservation Planning." AWWA Conserv '93 Proceedings, December 12, 1993.

W. B. DeOreo, E. A. Payton, D. Kralicek, D., and N. Munns. "Development of a Water Supply Operation Model for the City of Northglenn, Colorado." Proceedings of American Water Resources Association Symposium on Transferring Model to Users. Denver, Colorado, 1990

C. M. Brendecke , W. B. DeOreo, E. A. Payton, E. A., and L. T. Rozaklis. "Network Model of Water Rights and Systems Operations." ASCE Journal of Water Resources Planning and Management, 115 (September 1989)

R. L. Wheeler, W. B. DeOreo, E. A. Payton, and C. M. Brendecke. "Use of Network Optimization Techniques to Simulate Operation of Municipal Water Systems." Paper presented

at ASCE Water Resources Planning and Management Division, Kansas City, Missouri, 1987

W. B. DeOreo. "Assessment of Costs to Private Developers and Municipal Governments for Institution of an Erosion Control Program." Paper presented at University of Kentucky Conference on Urban Drainage, 1982