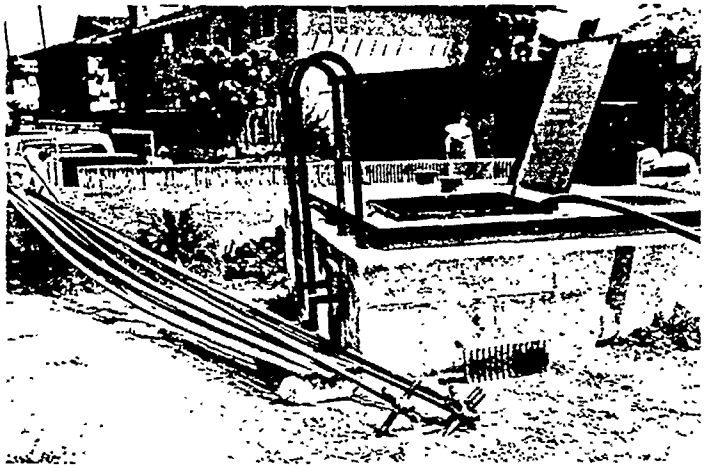
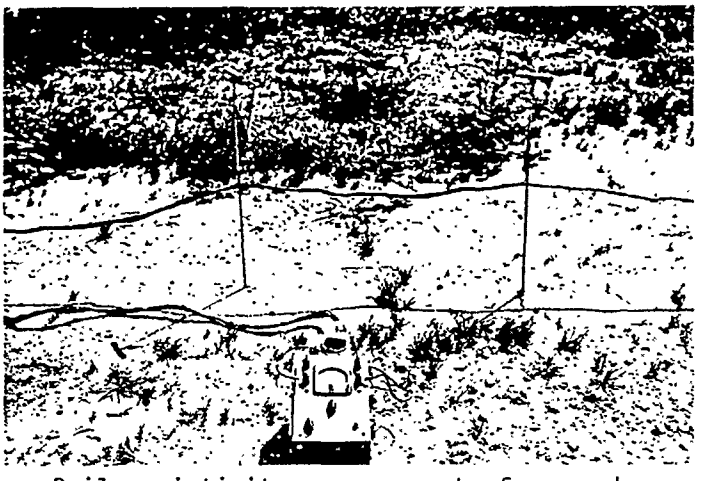
AWWA RESEARCH FOUNDATION
Water Quality Research News

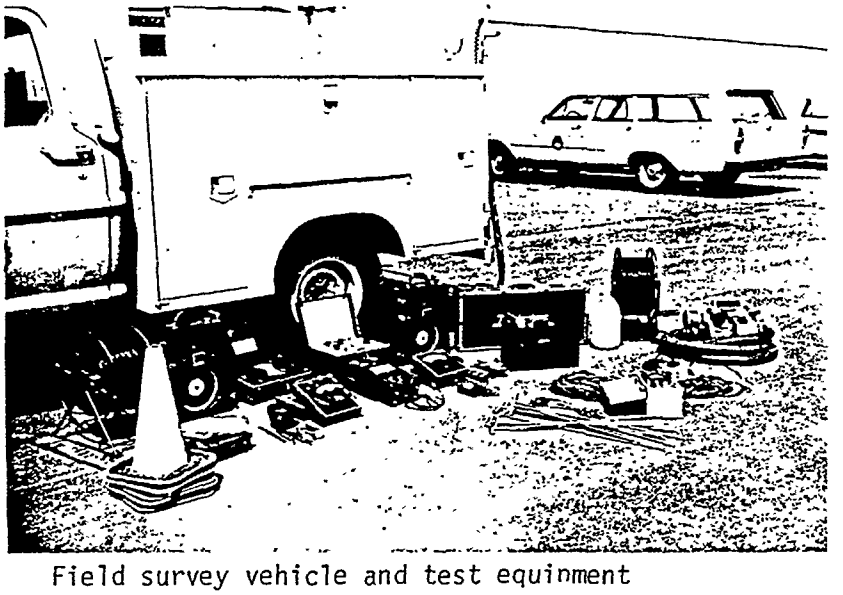
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA DEFENDS AGAINST CORROSION WITH ELECTROLYSIS SURVEYS AND CATHODIC PROTECTION



Polyvinyl-chloride pipe to which anodes are attached for deep-well anode-bed installation on the right-hand side of the structure



Soil resistivity measurement--four-probe method with two probes pictured



Field survey vehicle and test equipment

(Photos furnished by MWDSC)

AWWA Research Foundation/6666 W. Quincy Ave./Denver, CO 80235/Ph.: (303) 794-7711

Pipeline Protection at The Metropolitan Water District of Southern California

Cathodic intervention minimizes pipeline corrosion at MWDSC. Deep anode groundbed installations still perform well after many years of operation.

Makeup of Distribution System. The more than half-billion dollars invested in 600+ miles of steel, precast concrete, or prestressed concrete pipes in a 28-246 inch size-range fight internal corrosion with interior water-contact surfaces of mortar or concrete and a concrete or dielectric-membrane coating on the outside of the steel cylinder or reinforcing steel cage.

Many of MWDSC transmission mains align in close proximity to steel pipelines transporting hazardous material, and being much longer tend to attract stray currents from these "foreign" cathodically-protected pipelines. Electrolysis due to uncontrolled stray direct currents that enter the pipe travel some distance and then discharge from the pipe to the soil, presenting a major problem. Constant modification of cathodic protection systems necessitates continuous updating of information on potentials and current flows on every pipeline, so that the suffering party can return enough stray currents to the offending pipeline to restore the normal potential.

Detection of Corrosion Sites. *Pipe-to-Soil Approach.* Generally, pipe-to-soil potentials of noncorroded steel in concrete fall within the range of 100-300 millivolts (mV) negative to the copper/copper-sulfate half-cell electrode (CSE). Dielectrically-coated steel produces CSE measurements of 300-700 mV, depending on the condition of the protective coating. Higher potential readings betray areas of probable corrosion with close-interval measurements narrowing down the points of stray-current discharges from the pipeline.

Line-Current Approach. MWDSC commonly relies on a low-range potentiometric recording instrument, connected to the metal pipeline at distances varying from 100 to more typically about 1000 feet (ft), to record the potential drop for a period of 20-24 hours. The accumulated data enable calculation of the average current flowing along the pipeline.

Such a survey can establish the magnitude of long line currents that may enter or leave unprotected steel pipe, triggering corrosion in areas of current discharge to the soil, and in the case of cathodically-protected pipelines can determine whether the system is operating properly, and also ascertain whether insulating sections installed in the pipelines to isolate stray currents are functioning.

Stray currents on dielectrically-coated pipe evoke concern because such discharges denote the locales of damaged coating and the possibility of a perforated steel cylinder in a relatively short time. In the absence of stray currents, corrosion of the steel cylinder can occur at points of coating damage at a rate dictated by the aggressiveness of the soil to which the pipe is exposed.

Cathodic Strategy. Cathodic measures ward off corrosion by passing direct current continuously from electrodes installed in electrolytes such as soil or water back to the structure to be safeguarded. Corrosion diminishes when current of sufficient magnitude counteracts the flow from the pipe and properly distributes along the length of affected pipe. The cathodic system also provides supplemental protection to immersed water-treatment equipment and interior surfaces of water tanks.

Installation. The process at MWDSC often involves a deep-well anode groundbed adjacent to the pipe and a rectifier power source for the direct current. An assembly of twenty 3x30-inch graphite anodes, equally spaced, is lowered into a 300-ft deep hole, backfilled with calcined petroleum coke breeze from the 300-ft to the 200-ft depth, and then topped with grout from the 200-ft level to the surface. Soil resistivity measurements prior to groundbed installation locate the most favorable region of placement and ensure optimum protective-current delivery. Adjustment of the rectifier current returns the pipe to the "normal" potential.

Operating Experience. An excessive impressed cathodic-protection voltage can induce coating failure in a dielectrically-coated pipe, water-tank lining, and submerged water-treatment equipment.

Electrolysis surveys along a MWDSC pipeline in 1965 disclosed a current discharge of 1.5 amperes within a 700-ft section of gunite-coated pipe (electrically bare). Ensuing pipe-to-soil measurements pinpointed the position of discharge in a poorly-aerated soil.

Installation of the typical anode array between 130 and 240-ft depths of a 260-ft deep well required an unusually high current to return the pipeline to the desired pipe-to-soil potential. After 10 years the effectiveness of the rectifier began declining, and following several unsuccessful attempts to increase the conductivity of the bed by water injection into the well the installation failed completely three years later.

Electrolysis surveys immediately thereafter demonstrated little if any discharge of current at the original point and partial polarization. Within another three years current resumed flowing from the pipe. Soon a new deep anode groundbed will be required to control this current flow and will include high-silicon/chrome/iron anodes more suited to the severe demands of this site.

Preventive Activities. A corrosion-control section within the construction branch of MWDSC monitors the mains for possible corrosion sites. Several two-person crews perform electrolysis surveys along all existing pipelines for flows of stray direct currents. Each crew averages two line-current survey setups per work day, enabling a complete round of the distribution system in $2\frac{1}{2}$-3 years. Monthly monitoring of the cathodic-protection stations and quarterly pipe-to-soil potential surveys of cathodically-protected pipelines ensure appropriate operating conditions.

Additionally, the crews test for cathodic interference between MWDSC installations and "foreign" substructures, check dielectric effectiveness of

insulating flanges, monitor and maintain filtration-plant cathodic-protection devices, and introduce new units as needed.

Other personnel monitor pending engineering tasks, recommend specifications for the various construction materials, evaluate coatings for resistance to weather and soil, and measure the corrosive effect of selected ions to metals in aqueous environments.

A report on these matters was presented by A. E. Bowers, W. E. Risner, and L. Grasha at the AWWA Water Quality Technology Conference held December 6-9, 1981 at Seattle, Washington. For more information, contact:

Eugene Bowers
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DISINFECTION

Ultraviolet Irradiation of Coliforms

Irradiation with either broad-spectrum near-ultraviolet (fluorescent black light blue, BLB) or monochromatic wavelengths in the near-ultraviolet (UV) range of 320-400 nanometers (nm) can cause specific damage to the deoxyribonucleic acid (DNA) of the radiation-sensitive variant *Escherichia coli* K12 AB2480 at the stationary phase of growth.

Both monochromatic radiation in the wavelength range 334-380 nm and broad-band near-UV BLB radiation (313-405 nm) produce cyclobutylpyrimidine dimers in sufficient yield to account for many of the biological effects observed. The radiation can also induce various additional DNA lesions, including DNA single-strand breaks, alkali-labile bonds, and pyrimidine glycols.

Genetic damage by near-UV radiation is not limited to bacteria. Mouse, hamster, and human cells may also be susceptible.

Information source: R. B. Webb and M. S. Brown, "Genetic Damage in *Escherichia coli* K12 AB2480 by Broad-Spectrum Near-Ultraviolet Radiation", *Science*, 215:991 (19 February 1982).

ENERGY

Solar-Powered Pump Systems

Field and laboratory trials testify that small-scale sun-powered irrigation pumping systems bear improvement to compete economically with conventional methods at the present stage of development.

The first phase of a project, conducted under the auspices of the World Bank and the United Nations, appraised solar-energy systems on typical small plots in three nations during the July 1979-May 1981 period. The 50-cubic meters per hectare per day of irrigation water originated at well depths of roughly five meters (m), requiring a hydraulic power output of 100-300 watts (W).

Extent of the Tests. Eleven photovoltaic (PV) arrays with a rated power of 75-1200 W (median 480), available in early 1980, underwent field testing in Mali, Philippines, and Sudan, four each in the first two countries and three in the last. The lone thermal system of 5.1-square meters array operated in Sudan. The indigenous energy research agency collaborated in each undertaking.

Simultaneously, similar motors and pumps in the field-tested PV systems were laboratory-tested in Great Britain to ascertain performance characteristics. Independent authorities in the United Kingdom (UK) and USA also performance-tested sample PV modules.

Seven manufacturers in France and the USA, six in the UK, and one in India, Israel, Japan, and West Germany supplied PV modules and subsystems, individual motors and pumps, and thermal systems and components for laboratory evaluation.

Field Trials. The dozen systems checked included nine PV, one thermal, one a duplicate PV, and an existing PV installation in Mali. The trials assessed where possible: cumulative solar irradiation; power, voltage and/or current output from the array; solar irradiance at any instant (global and in plane of array); pumped head and flow rate at any instant; static head at any instant and average over the day, and cumulative volume pumped over a day.

A permanent framework on a concrete foundation fixed the fully-tested PV system so that the array would tilt optimally for the latitude of each site. A portable unit with a hand-adjustable array departed from this pattern.

Pumps. Single-stage centrifugal pumps, some surface mounted, some submerged, provided the lift between three and 20 m, usually under 10 m. Two positive displacement (piston) pumps, a regenerative turbine pump, a submerged multistage centrifugal pump already on the scene in Yangasso, Mali, and a low-speed reciprocating piston pump also participated in the program.

Two of the surface-mounted centrifugal pumps at Korofina, Mali and Talampas, Philippines failed to retain prime due to excessive suction heads. Although operating close to their design total static lift, both proved less efficient than expected due to air in the eye of their impellers.

Non-self-priming centrifugal pumps generally fail to meet solar-power demands because stoppage or slow operation caused by cloud intrusion induce foot-valve leakage and loss of prime. Running dry can wear out seals and bearings which depend on water for lubrication.

The best solar pumps embody motor-pump subsystems with efficiencies approaching 40% versus 20% for the worst. Positive displacement pumps were judged deficient on efficiency and size grounds for small-scale irrigation. Simple, single-stage centrifugal pumps combine adequate performance with compactness and low starting-torque.

Array Performance. Array efficiency varied between 4.8 and 8.5%, determined by the impedance match between the array and its electrical load. A low start-up irradiance permits the unit to activate earlier in the day and switch off later. One tracking system contained an electronic device which continuously adjusts the voltage output of a PV array to an optimum value, maximizing the power output.

A manually-tracked array offered a 30% increase in water output per day, translating into a 20+% reduction in specific capital cost. Nonetheless, additional comparison of manual and automatic tracking is warranted.

Motor Selection. The more expensive direct-current permanent-magnet motors enabled superior efficiency under part-load conditions. In the 250-500 W range the motors can show optimum efficiencies of 85% and even at half load should exceed 75%.

Overall Efficiency. The field trials indicated that well-designed systems should function consistently with efficiencies (based on array area) of over 2% and under favorable circumstances attain 3%. However, only three systems exceeded 2%, two commercially available while the third, a special product fabricated for the project, proved one of the most cost-effective in terms of capital cost per peak watt of output.

Only one borehole system performed faultlessly during the test period, its bugs eliminated by earlier installation. The operating experience emphasized the propriety of adequate field trial in advance of marketing.

Future Plans. The researchers set the following efficiency targets for the succeeding generation of systems: array cells 11%, connections 95%, motor 85%, pump 55%, pipework 95%, total system 4.6%, equivalent to the best systems tested so far. Capital cost of such a system should approximate $2.5 per kilojoule per day.

The second stage of the project, now in preparation, may involve sun pumps in drinking-water applications.

Two volumes, *Phase 1 Project Report* and *Technical and Economic Review*, available from the World Bank, describe the United Nations Development Program Small-Scale Solar-Powered Irrigation Pumping Systems Project GLO-78-004. A digest of the contents under the title "Ideal sunpump system still eludes researchers" appears in *World Water*, page 22 (January 1982).

PROJECT SUPPORTED BY THE AWWA RESEARCH FOUNDATION

In-Well Aeration Research at North Penn Water Authority

A $90,000 grant from the US Environmental Protection Agency, supplemented by additional financial contributions, will enable the North Penn Water Authority (NPWA) to study the removal of volatile organics from groundwater supplies by in-well aeration.

History. As early as the 1920s compressed air lifted water from wells to a surface tank before onward pumping to the community's distribution system. Following the discovery in August 1979 of trichloroethylene (TCE) in several NPWA wells, experiments indicated that the air-lift pumping process simultaneously removes 90% of the TCE.

Proposed Research. The contemplated investigation will also explore several other in-well aeration systems. The recently-completed laboratory facilities at NPWA, equipped with the latest state-of-the-art gas-chromatography instrumentation, will determine the organic contaminants and other required constituents.

Financing. A $10,000 commitment from the AWWA Research Foundation, together with a contribution from the Upper Southampton Municipal Authority, a Bucks County water utility beset with similar groundwater-contamination problems, and support from the Pennsylvania Science and Engineering Foundation, will help to defray the estimated cost of $174,530 for the project's first phase.

If the research succeeds, the NPWA hopes to construct a 50-gallon per minute pilot plant teaming the in-well aeration process with carbonaceous resin adsorption.

A $70,000 carbon treatment plant in service for two months continues to remove TCE below the detection level. The aeration research aims to develop a less-expensive method of expelling volatile organics from drinking water.

For more information, contact:

H. J. Borchers, Jr.
North Penn Water Authority
200 North Chestnut Street
Lansdale, Pennsylvania 19446
Telephone: (215) 855-3617

PROJECT FUNDED BY THE AWWA RESEARCH FOUNDATION

Manual on External Corrosion

The AWWA Research Foundation Board of Trustees has approved funding for the development and production of a manual concerned with the external corrosion prevalent in the water-supply industry from source to distribution system.

The text will cover the accepted methods of detecting external corrosion and the necessary measures for coping with the problem. The primary focus will center on practical application.

The AWWA Research Foundation invites individuals interested in completing such a task within the next year to submit a notice of intent by March 31, 1982.

Please do not submit a proposal at this time, an indication of interest alone will suffice. A comprehensive request for proposal is under development and will be issued to all interested parties.

Please contact by mail or phone

Michael Taras, Project Engineer
AWWA Research Foundation
6666 West Quincy Avenue
Denver, Colorado 80235
Telephone: (303) 794-7711

TECHNOLOGY TRANSFER

The Research Foundation has initiated a technology transfer program and we want you to be part of it. Frankly, your help is needed, for as the number of participants increases so does the value of the program to the entire water supply industry.

Our goal is to be able to tell you who is doing, or has done, or plans to do what and where. Like all utility operators, you have problems or are looking for better ways of doing things. To solve those problems or find better ways, you search the literature to learn what others have done and then go to work. Unfortunately, much of what has been done or is being done will never appear in the literature. Some of the work may be recorded in memos or internal reports; the rest is only in the minds of those who did or are doing it. That's the information we're after, and only you and your associates can supply it. Once in our computer data base, it will be easy to find and available to those who need and can use it.

We're looking for information on all phases of water supply--resource, quality and treatment, distribution, metering and billing, maintenance, management, etc. That information should include research; problem solving; evaluation of new processes, materials and treatment; applications of new ideas; etc.

It is also important to know about the ideas and approaches that have not worked, as well as those that have. That information can save others considerable time, effort and money, and may lead to approaches and ideas that do succeed.

The Research Foundation's program is designed to collect and store unpublished material that has not appeared in the JOURNAL AWWA, Conference Proceedings, or other major publications. Internal project reports, memos and papers presented at meetings but not printed in the JOURNAL AWWA or Conference Proceedings or other major publications are considered unpublished and candidates for the program. And, of course, there's that vast amount of information that has never been documented in writing but is very useful to others.

If you have solved one or more problems, are now engaged in research or problem-solving activities, or plan to do so soon, please tell us about it. Include the little projects too, not just the big ones. Anything you feel will be of help to others.

On the other side of this page we have printed a form you can duplicate and use to tell us about your problem-solving activities. Or, if you wish, you can use plain paper. But be sure to include as much of the requested information as possible. If you have written material on the work, whether it be in the form of an internal report, memo or paper, a copy would be appreciated. After putting the information on coding sheets we'll send copies to you for review, correction and additional information if needed, before keying it into the computer data base.

Here is an opportunity to help others and yourself through the exchange of information not available in the literature. We urge your participation and thank you for it.

RESEARCH PROJECT DESCRIPTION

- Please use this form to provide information on work completed, now underway, or planned for the near future. Make extra copies of this form as needed. If you have written reports of work done or underway, a copy along with this form will be appreciated.
- Return the form and other material to:

Elroy F. Spitzer
AWWA Research Foundation
6666 West Quincy Avenue
Denver, Colorado 80235

TITLE _____

_____

NAME OF ORGANIZATION _____

_____

ADDRESS _____

CITY & STATE _____ ZIP _____ PHONE _____

PRINCIPAL CONTACT _____

PROJECT DESCRIPTION: OBJECTIVE AND APPROACH _____

_____

_____

_____

_____

RESULTS/BENEFITS APPLICATION _____

_____

_____

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_____

PROJ START DATE _____ COMPLETION DATE _____

ESTIMATED COST _____

(Please use separate sheet if additional space is needed)

Cut Line

TREATMENT

Control of Lead Concentrations

Two treatment attacks: pH correction and addition of orthophosphate can cut lead concentrations derived from lead pipes and other plumbing fittings. Elevation of pH in soft moorland waters constitutes an established practice in Great Britain. Resort to phosphates is much less common and primarily directed to thwarting the corrosion of iron mains. Care and monitoring are desirable during the early stages of phosphate application to identify possible problems.

Examination of pipe deposits, calculated solubility, and empirical tests offer a consistent picture of dissolved lead from the deposits approaching a concentration limited by the solubility.

Investigations in the United Kingdom and Holland relate lead gains with the time the water spends in the pipe. The concentration rises rapidly for three to four hours, levels off, and then climbs gradually toward a steady state.

A sound theoretical base exists for predicting the effects of treatment particularly in the case of low-alkalinity water where depressed pH clearly emerges as a cause of plumbosolvency.

Although results from different waters of low alkalinity agree reasonably well, the substantial variability of lead concentration within a single test and between tests of the same high-alkalinity water impede efforts to establish a comparable simple relationship.

pH Adjustment. *Low-Alkalinity Water.* The generally-low alkalinity, total dissolved solids, and pH spawn high lead concentrations in waters of moorland origin. Raising the pH curtails the solubility of basic lead carbonate prevalent in the pipe deposits.

A pH of about 8.5 and not below 8.0 at the consumer's tap minimizes the lead presence in low-alkalinity water containing less than 50 milligrams per liter (mg/L) of calcium carbonate.

A high standard of equipment performance, operation, and maintenance of the pH correction system, along with continuing vigilance over the practical aspects of alkali dosing, becomes imperative in low-alkalinity supplies.

High-Alkalinity Water. Calcium carbonate precipitation severely restricts upward pH adjustment of high-alkalinity, customarily-hard waters to a maximum pH near 8.0. Within this range only a minor change takes place in lead solubility at an alkalinity of 200-250 mg/L calcium carbonate.

Carbonate removal by softening, or possibly by dosing with acid, aeration to expel carbon dioxide, and final pH escalation entail extra facilities. Laboratory experiments verify the effectiveness of these relatively unattractive options, confirmed by results in The Netherlands.

Orthophosphate Feed. *Low-Alkalinity Water.* Phosphate treatment of a moorland water forms lead phosphate in addition to the residues already in the pipe from decades of exposure, typically hydrocerussite covered by organic peaty material.

A relatively-expensive chemical, orthophosphate provides a valuable alternative in instances where pH correction fails to lower the lead concentration to a satisfactory point. The agent can also answer the prayers of small isolated plants lacking consistent and reliable pH control.

High-Alkalinity Water. Orthophosphate attains preferential status for water of high alkalinity because of the inability of pH correction alone to achieve the desired results, and softening or removal of alkalinity have serious disadvantages. Dosing with phosphoric acid possesses two virtues in such cases: lower cost compared to sodium phosphates and generally the production of minimal pH variance.

The paucity of knowledge on the formation and properties of lead phosphate deposits in pipes applies equally to high and low-alkalinity waters. A cautious path of trials with detailed monitoring of effects should precede the wide adoption of phosphate treatment.

Other Considerations. Despite the body of evidence pointing to solubility as the most important general influence on lead levels, many other factors may be significant in some circumstances. Large lead concentrations may ensue from disturbance which disrupts the deposits in lead pipe. Such local conditions remain beyond treatment-plant reach. Iron, aluminum, and other material in suspension, and organic compounds typify substances that may also play a role in the complete picture of lead in water.

Future Research. Solubility calculations provide scientific support for reducing lead concentrations during the treatment of both high and low-alkalinity waters. Increasing the pH often abates the high lead levels associated with low-alkalinity water and low pH. No such simple relationship prevails in the case of high-alkalinity situations. The contribution of the solid hydrocerussite in deposits to high lead levels in high-alkalinity water merits attention. Other matters deserving scrutiny include water likely to develop excessive lead levels, the preferred treatment methods, and the influence exerted by soluble and insoluble organic compounds.

This investigation, conducted by I. Sheiham and P. J. Jackson at the Water Research Centre in Great Britain, is described at considerable length under the title "Scientific Basis for Control of Lead in Drinking Water by Water Treatment" in *Journal of The Institution of Water Engineers and Scientists*, 35:491 (November 1981).

Consult page 4 of the December 1981 issue of this publication for a related lead study in Scotland.

US ENVIRONMENTAL PROTECTION AGENCY

New Policy on Internal Peer Review

Effective January 18, 1982,"...scientific or informational material attributable in any way to the United States Environmental Protection Agency (EPA) and prepared by an EPA employee, consultant, contractor or grantee for distribution outside the Agency must be reviewed and approved through a new control system...Any material prepared for distribution to anyone outside the agency is considered a 'public' informational product..."

Exempted are congressional testimony and officially-approved notices, releases, documents, and statements.

"...The extent to which EPA produces informational materials will be determined by Agencywide priorities and the availability of resources...and must fit into one of the following categories: mandated materials, regulatory and enforcement baseline and compliance materials, and scientific, technical, informative and educational materials...

"...Major products must be reviewed by (the Administrator's) Science Advisor and/or by the Office of Public Affairs...If a product of any cost contains significant scientific or technical uncertainties, it becomes a 'major' document subject to review by the Science Advisor or his designated representatives...

"If a product does not require review by either the Science Advisor or Office of Public Affairs, (Associate, Assistant, and Regional Administrators, and Staff Office Directors) are accountable for adequate peer review and cost control...

"...At least two peer reviewers, specialists in the subject, will evaluate the manuscript for general content, organization and scope, presentation and quality of data, validity of analytical techniques, soundness of conclusions and consistency...Refusal at any level of management to approve a document may be appealed once to the next higher level of management...

"...The new peer review and budgetary controls (aim to) assure that all Agency materials are result-oriented, cost effective, consistent with Administration policy, and are based on the best scientific and technical evidence available...

"...EPA encourages the independent publication of the results of its contract and grant research in appropriate scientific journals as an important method of recording and reporting scientific information..." Therefore, such journal articles are not subject to the Agency's required peer and policy review.

WATER QUALITY

Effects of Forest Fire on Water Quality

Controlled burning in forest management, a practice applied annually to about a million hectares of pine stands in the southeastern US, causes limited effects on soils, nutrient cycling, and hydrologic systems of experimental watersheds in South Carolina.

Hydrologic fluxes of nitrogen, phosphorus, sulfur, and basic cations, from burned pine litter to ground and stream waters are unlikely to exert appreciable impacts on water quality in the Atlantic and Gulf Coastal Plain. In this region, prescribed fire reduces the risks of natural wildfire, controls certain tree pathogens, manipulates the density and composition of understory vegetation, and promotes food and habitat for wild and domestic animals, all with a remarkable degree of economy.

Ground Water. A 32-well network, located in burned and unburned areas of the treatment watershed and sampled weekly in pre and postburn periods, evaluated the consequences of fire on the groundwater chemistry. The low concentrations of nitrate-nitrogen, ammonium-nitrogen, and orthophosphate-phosphorus throughout the 20-week sampling period averaged about 0.01, 0.20, and 0.02 milligram per liter (mg/L), respectively, in surface soil horizons, and 0.006, 0.03, and 0.01 mg/L, respectively, in subsoil horizons. Periodic sampling for one year after the burns indicated no effects of fire on pH or specific conductance.

Surface Water. During 1976-1979 paired, gaged watersheds evaluated the effects of prescribed fires on stream water quality. After one year in an undisturbed condition (1976), a sequence of six prescribed fires was administered winter and summer to a total of about 60% of the treatment watershed over a 2.5-year period (1977 to mid-1979), in accordance with normal management of many pine stands in the coastal plain (five-year fire cycle).

Weekly stream sampling conducted over a 3.5-year interval revealed no changes in the total nitrogen, ammonium, nitrate, orthophosphate, sulfate, chloride, calcium, magnesium, potassium, sodium, bicarbonate, and hydrogen ions, attributable to the fire treatments.

Volume-weighted stream-water concentrations of nitrate and ammonium nitrogens, and orthophosphate phosphorus averaged about 0.02, 0.03, and 0.03 mg/L, respectively, in water draining from both burned and unburned watersheds, with insignificant differences between the pre and postburn periods.

Several reasons account for these results. The prescribed fires consumed less than one-third of the forest floor mass composed of pine litter materials of low ash content. Unburned litter and soil layers filtered the suspension of ash particulates and solutions of water-soluble elements prior to emergence as stream flow.

Additional filtration intervened in the 20-meter wide unburned buffer strips adjacent to stream channels. Lastly, fire treatments on a five-year cycle introduced a substantial dilution factor because stream water collected at the weir included runoff from both torched and untorched portions of the treatment watershed.

Samplings at points immediately upstream and downstream of burned compartments disclosed no detectable fire effects on the chemical composition of stream water.

Information source: D. D. Richter and C. W. Ralston, "Prescribed Fire: Effects on Water Quality and Forest Nutrient Cycling", *Science*, 215:661 (5 February 1982).

AWWA Research Foundation
6666 West Quincy Avenue
Denver, Colorado 80235

CAPCO PIPE COMPANY, INC.

Birmingham, Alabama

January 21, 1983

Lynn For your FILE

TO: Mr. Bruce Klomfas

FROM: Ms. Gloria Jones

SUBJECT: AWWA, ASTM and ANSI Specifications

Mr. Leyshock asked that I send you a copy of the AWWA, ASTM, and ANSI specifications which apply to A/C pipe. Enclosed are the following specifications:

AWWA C400-77	—	Asbestos-Cement Distribution Pipe, 4 In. through 16 In., for Water and Other Liquids
AWWA C401-77	—	Standard Practice for the Selection of Asbestos-Cement Distribution Pipe, 4 In. through 16 In., for Water and Other Liquids
ANSI/AWWA C402-77	—	Asbestos-Cement Transmission Pipe, 18 In. through 42 In., for Water and Other Liquids
ANSI/AWWA C403-78	—	Standard Practice for the Selection of Asbestos-Cement Transmission and Feeder Main Pipe, Sizes 18 In. through 42 In.
ANSI/AWWA C603-78	—	Standard for Installation of Asbestos-Cement Pressure Pipe
ASTM C 296-72	—	Standard Specifications for Asbestos-Cement Pressure Pipe
ASTM C 428-81	—	Standard Specification for Asbestos-Cement Nonpressure Sewer Pipe
ASTM C 644-76	—	Standard Specification for Asbestos-Cement Nonpressure Small-Diameter Sewer Pipe
ANSI/ASTM C500-77	—	Standard Methods of Testing Asbestos-Cement Pipe
ASTM C 668-81	—	Standard Specification for Asbestos-Cement Transmission Pipe
ASTM D 1869-78	—	Standard Specification for Rubber Rings for Asbestos-Cement Pipe

Gloria

gj
Enclosures

Copy to: Mr. S. G. Leyshock

REMEMBER

ALL BOOTH PERSONNEL MUST BE REGISTERED AND MUST COMPLETE A REGISTRATION FORM.

ALSO, YOUR REGISTRATION MUST ACCOMPANY YOUR REQUEST FOR ACCOMMODATIONS.

Attached, for your convenience, is an extra copy of the registration form.

AWWA 1984

NAME FOR BADGE _____

TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ STATE OR PROVINCE _____ ZIP _____

COUNTRY _____ PHONE ____ - ____ - ____

SPOUSE OR GUEST _____

CONFERENCE REGISTRATION

REGISTRATION FEES-(circle choices)

		Before May 25	After May 25
Technical—Sessions & Exhibits			
With Banquet (incl. Fun Night)	A	$245	$295
Without Banquet (incl. Fun Night)	B	210	260
Monday Only	C	75	95
Tuesday Only	D	75	95
Wednesday Only	E	75	95
Thursday Only	F	75	95
Student-(college or university)	G	10	15
Exhibits Only			
Sun.-Wed.	H	10	15
Exhibitor complimentary	J	-	
EXTRA COST			
Fun Night ____ @ $20	T	____	
Fun Night-Child (under 12) ____ @ $12	R	____	
Extra Banquets ____ @ $35	K	____	
Facility Tours:			
East Side Purification Plant-Mon.	P	15	20
White Rock N. Wtr. Transmission-Tue.	N	15	20
Central Control & Meter Repair-Tue.	O	15	20
Wastewater Trtmt. Pl. Research Lab-Wed.	L	15	20
Ultra Pure Water Plant at TI-Wed.	M	15	20
Seminars-Sunday:			
Hydraulics	U	75	100
Chloramination	V	75	100
Groundwater Contamination	W	75	100
Financial Programs (1/2 Day)	X	40	55
Non-specific Organic Analyses	Y	75	100
Conference Proceedings	Z	45	45

		Before May 25	After May 25
Spouse-Hospitality Exhibits & Favor			
With Banquet (incl. Fun Night)	SA	$70	$90
Without Banquet (incl. Fun Night)	SB	35	55
EXTRA COST			
Spouse Tours:			
Even J.R. Loves Dallas	SV	14	14
Discover Dallas	SU	13	13
Dallas Homes-Tue.	ST	18	18
Fashionably Dallas	SS	30	30
Where The West Begins	SR	15	15
Antique And Unique	SQ	12	12
Dallas Heritage Tour	SP	16	16
Shopping Dallas Style	SO	12	12
Art About Town	SN	28	28
Dallas Homes-Wed.	SM	18	18
Seminars-Wednesday			
Living Better-Feeling Worse	SL	5	5
New Insights-Meaningful Living	SK		

TOTAL COST-ALL REGISTRATIONS $ _____

____ Personal Check ____ Company Check

Make check payable to AWWA in US funds.

Credit Card No. _____

____ American Express ____ Visa ____ Mastercard

Expiration Date _____

Occupation (Circle One)

WTR	Water Utility	EDU	Educator
CTR	Contractor	RES	Research Lab
CON	Consultant	FED	Govt.-Federal
EXH	Exhibitor	STA	Govt.-State
MFG	Mfg-Not Exhibiting	LOC	Govt.-Local
REP	Mfgrs Representative	STU	Student
DIS	Distributor	OTH	Other ____

Choice	Hotel	Rate	Type (Circle One)	Name(s) of all Occupant(s)
1	_____	_____	Single	1 _____
2	_____	_____	Double	2 _____
3	_____	_____	Twin	3 _____

Send Confirmation to:

Name _____

Company _____

Address _____

City _____ State _____ Zip _____

Telephone No. _____

Arrival Date _____ Time _____

Departure Date _____

Requests received after May 18 are conditional on space availability.

DO NOT SEND DEPOSIT TO HOUSING BUREAU

AWWA 1984