OCEEDINGS

THIRD ANNUAL CONFERENCE
CALIFORNIA ASSOCIATION OF RECLAMATION
ENTITIES OF WATER

Watercare

Theme: Conservation Through Reclamation

PEPPERDINE UNIVERSITY ▪ MALIBU CAMPUS
JUNE 10-11, 1976

P R O C E E D I N G S

THIRD ANNUAL CONFERENCE

CALIFORNIA ASSOCIATION OF RECLAMATION ENTITIES OF WATER

Theme: *Conservation Through Reclamation*

Local Host: *Las Virgenes Municipal Water District*

Pepperdine University, Malibu Campus

June 10 - 11, 1976

CONFERENCE COMMITTEE

H. W. Stokes, Chairman
George W. Adrian
Eugene Bowers
John G. Joham, Jr.

PURPOSE OF WATERCARE

Watercare was incorporated in 1974 as a non-profit corporation to sponsor and conduct research into water reclamation and reuse, and to promote the extension and improvement of public water supplies through employment of new water sciences.

DIRECTORS OF WATERCARE

Lloyd C. Fowler, President Watercare
Santa Clara Valley Water District

H. W. (Will) Stokes, Vice President Watercare
Las Virgenes Municipal Water District

Neil M. Cline, Secretary Watercare
Orange County Water District

George W. Adrian
Department of Water and Power
City of Los Angeles

Howard Bensen
City of Santa Barbara
Public Works Department

Dennis E. Maclain
Municipal Water District of Orange County

John Olaf Nelson
North Marin County Water District

Linda K. Phillips
Goleta County Water District

Polly O. Smith
Marin Municipal Water District

William E. Warne
Water Resources Development Consultant
Sacramento

HOW TO JOIN WATERCARE

Individuals may join WATERCARE as Associate Members. Current Assoicate dues are $15/yr.

Public Agencies may join WATERCARE as Participating Members. Current Participating dues are $500/yr.

FOR FURTHER INFORMATION WRITE:

WATERCARE
5750 Almaden Expressway
San Jose, California 95118

CONTENTS

Page

THEME - CONSERVATION THROUGH RECLAMATION 2
by Lloyd Fowler, President, WATERCARE

PERSPECTIVE ON QUALITIES OF RIVER WATER 6
by Dr. Edward J. Cleary, Adjunct Professor of Environmental Health, University of Cincinnati

SUMMARY OF EUROPEAN METHODS OF RIVER TREATMENT AND RE-USE 18
by Franklin Dryden, Chief of Technical Services, Sanitation Districts of Los Angeles County

WINDHOECK SOUTH AFRICA'S WATER TREATMENT AND RE-USE 26
by William Seeger, Kennedy Engineers

MORNING SESSION SUMMARY 69
by George W. Adrian, Director, WATERCARE

PUBLIC HEALTH CRITERIA FOR RECLAIMED WATER REUSES (Title 22) 72
by William Jopling, State Department of Health

PUBLIC HEALTH CRITERIA AND RATIONAL FOR GROUNDWATER RECHARGE 81
by William Jopling, State Department of Health

BLUE RIBBON PANEL AND STATE WATER RESOURCES CONTROL BOARD ACTION PROGRAM ON WASTEWATER RECLAMATION 92
by Jan Stofkoper, Office of Planning, State Water Resources Control Board

PANEL DISCUSSION: BENEFIT VS. RISK FROM RECLAIMED WATER - IN PERSPECTIVE 108
MODERATOR - Dr. Gerald H. Meral, Department of Water Resources

PRESENTATION - by Dr. John Goldsmith, California State Department of Health 109

PRESENTATION - by Dr. Ronaly A. Howard, Department of Engineering of Economic Systems, Stanford University 112

PRESENTATION - by Dr. Warren Winklestein, Dean, School of Public Health, University of California, Berkeley.......................................116

COMMENTS AND QUESTIONS 117

CRITIQUE OF DISCUSSION GROUPS 124
MODERATOR - Dr. Linda K. Phillips, Goleta County Water District

DUAL LINES - AVALON, CATALINA ISLAND
by George Crum, Southern California Edison Company 125

Page

BASIN RECHARGE - WHITTIER NARROWS.........................129
by Robert P. Miele, Sanitation Districts of Los Angeles County

CREEK DISCHARGE AND IRRIGATION - LAS VIRGENES.............133
by M. E. Ford, Boyle Engineering, Ventura

INJECTION TO REPEL SEAWATER INTRUSION - ORANGE COUNTY AND SANTA CLARA VALLEY WATER DISTRICTS.....138
by Nereus Richardson, Orange County Water District

ENERGY REQUIREMENTS OF ALTERNATIVES IN WATER SUPPLY..............140
by Robert M. Hagan and Edwin B. Roberts
University of California, Davis

METHODOLOGY FOR DEVELOPING AN ADEQUATE DRINKING WATER STANDARD WHICH IS INDEPENDENT OF SOURCE..........................189
by Dr. Carole Tate and Dr. Rhodes Trussell,
J. M. Montgomery Engineers

SUMMATION AND CLOSING STATEMENTS.................................226
by Jean Auer, Member, California State Water Resources Control Board

THIRD ANNUAL MEETING OF MEMBERS OF WATERCARE - MINUTES...........230
Lloyd C. Fowler, President
Neil M. Cline, Secretary

Theme: CONSERVATION THROUGH RECLAMATION

By

Lloyd C. Fowler - President, WATERCARE

General Manager,
Santa Clara Valley Water District

Presented at the Third Annual Conference, WATERCARE, "Conservation Through Reclamation", June 10-11, 1976, Pepperdine University, Malibu Campus.

CONSERVATION THROUGH RECLAMATION

by

Lloyd C. Fowler
President, WATERCARE

The objective of WATERCARE can be summarized to be the desire to extend the community water supplies. This extension can be through water conservation, or savings, practices and water reclamation and reuse. Good water management requires careful use of the available water; this includes water savings and reuse, which when exercised extend the community water supply.

Water savings, the reduction of consumption, is equivalent to increasing the available supply. Reuse is also equivalent to increasing the water supply. But, are both compatible in the same system? Will reducing consumption increase the dissolved solids content of wastewaters, thereby reducing the reclamation and reuse potential? Is it possible that by directing reuse into the supply system we can blend better quality water with reclaimed water to get an increased supply at acceptable quality levels?

These are questions WATERCARE should strive to answer. We will not be able to make full use of our ability to extend the community water supplies until such questions are answered. Every attempt at extension of the community water supplies will be impeded by these and other similar questions, including those concerning safety and degree of risk, and we must be prepared to answer these questions if we are to promote water savings and reuse.

According to health authorities, there are problems in reusing water. These involve the biological and chemical, both organic and inorganic, aspects of the wastewaters. The problems also extend to reliability and security of proposed processes for reclaiming wastewaters.

What will we have to do to intentionally reuse waters? This will depend on regulations to be adopted for any use other than irrigation. The requirements proposed for groundwater recharge include expensive and energy-intensive processes. These requirements may make reclamation and reuse uneconomic when compared to conventional methods of obtaining additional freshwater supplies. Even now, reclamation and reuse is hampered by the application of archaic terms of "cost effectiveness", "benefit-cost ratios", and "long-term firm contracts". These barriers need to be modified. WATERCARE can help by promoting education and completion of research activities and better defining environmental, social, and energy costs.

While it is essential that research and evaluation programs be developed to answer specific questions, it is also essential that programs of education be developed that bring water supply and waste disposal together. These programs must include water savings and reclamation as part of water supply and waste disposal activities. The importance of the total benefits derived from a pooled resource supply and disposal program cannot be overestimated. Good water management requires this. There is no other way that we can achieve a truly effective extension of the community water supply.

Reclamation and reuse of wastewaters is an effective means of conserving water. For example, recycling in a home by installation of a few simple plumbing systems can reduce the water requirements by half. Many years ago this was not uncommon. People saved washwater and used this to irrigate outdoor gardens and landscape. In some instances, washwaters were used to flush toilets. These in-home reuse systems can be reinstated through proper design and installation of simple plumbing units.

We can indeed save water by reuse. Unfortunately, we must face the fact that there is a great reluctance among the general public to knowingly reuse water, to use water someone else has discarded. It is only through education that this adverse public reaction will be overcome. Many studies have indicated public acceptance of various forms of water reuse, but when the individual is faced with the prospect of having to reuse water he or she turns away.

As an example, a recent proposal to extract groundwater from beneath an oxidation-percolation pond and apply this reclaimed water to irrigation of agricultural commodities met with hesitant acceptance by prospective users. As the project proceeded, negative statements by one individual emphasizing the questions raised by researchers on water reuse turned the market away from reuse. The individual farmers that constituted the market seemed to be relieved to accept the negative statements and use these as excuses for refusing to honor their previous commitments to accept the reclaimed water.

On another front, the proposed injection of reclaimed wastewater to create a barrier against seawater intrusion has been referred to by an international corporation as the pollution of underground water supplies by sewage waters. The reasons for the attacks by the corporation are unknown, other than an apparent desire to prevent use of the groundwater basin underlying their property. All the health problems and safety concerns expressed before are being raised again as the reasons why the project should not be allowed to proceed.

Public attitude surveys may indicate the public is willing to accept the reuse of water, but attempts at reuse are being blocked on every front by all sorts of individual concerns based primarily on emotion in spite of satisfactory reuse experience elsewhere.

WATERCARE has a job to do. While we can conserve water through reuse, we must recognize the difficulties faced by reuse. We can save water now. Let us do what we can to save water; let us educate communities and the public in this way to extend the community water supplies. And, by all means, let WATERCARE continue to try to promote the reuse of water; let us support demonstration projects; let us research and answer the questions doubters raise.

Let WATERCARE lead, push, pull, or do whatever is necessary to be an effective driving force that helps water agencies extend the community water supplies through water savings and reuse.

PERSPECTIVE ON THE QUALITY OF RIVER WATERS

By

Edward J. Cleary - Department of Environmental Health
University of Cincinnati, Ohio

Presented at the Third Annual Conference, WATERCARE "Conservation Through Reclamation", June 10-11, 1976, Pepperdine University, Malibu Campus.

PERSPECTIVE ON THE QUALITY OF RIVER WATERS

By

Edward J. Cleary

Department of Environmental Health

University of Cincinnati, Ohio

One of the more elusive aspects of water resources management is delineation of the status of river quality and the causes for its variability. Deficiencies in our knowledge of how things were and are in river quality, as well as in understanding the reasons why, constitute a significant handicap in making rational decisions for public policy and investment in the conduct of quality control measures.

For example, the 1972 amendment of the Federal Water Pollution Control Act (PL 92-500) opens with the statement: "The objective of this act is to restore and maintain the chemical, physical and biological integrity of the Nation's waters." The act then enunciates as national policy a series of steps leading to the goal of zero discharge of pollutants by 1985. It authorizes federal expenditures of $18 billion over a period of three years as an initial incentive for achieving this goal. The total investment from the public and private sector has been estimated at over $300 billion.

Those charged with administration of this act have reason to feel challenged. First, what yardsticks can be applied to measure the "chemical, physical and biological integrity of the Nation's waters?" A dictionary definition of integrity is: "the quality or state of being unimpaired." As applied to rivers presumably this envisions restoration of conditions that prevailed prior to any human influences. Unfortunately, historical records furnish few quantitative clues regarding what these conditions might have been.

From a social-welfare standpoint, an additional question arises: will the huge investment of funds looking toward the achievement of zero discharge of pollutants produce benefits in quality commensurate with costs? Such an assessment will call for a more sophisticated evaluation of river-quality conditions correlated with probable causes than is currently available. Limited investigations do suggest that the incremental benefits in going from 85 to 100 per cent removal of certain wastewater constituents may be inconsequential.

For guidence in the resolution of these and allied public policy issues it is obvious that broader encouragement be given to advancing the art of river-quality diagnosis. This situation provokes exploration of what do we know about past and present quality conditions. Also, it calls for some discussion of what we don't know or only dimly perceive concerning quality evaluation. And finally, it invites consideration of what the promise is for improving performance.

It is within this framework that I propose to sketch perspective on quality of river waters, primarily with respect to the situation in the eastern third of our nation. Rivers in this area have been for a long time the recipients of sewage and industrial waste discharges as well as serving as the principal source of water supply. Thus the indirect and involuntary reuse of soiled water -- often in the past discharged indiscriminately and without benefit of treatment -- is a well established fact.

For example, on the Ohio River a study in 1963 of water-use coupled with analysis of hydrologic records, showed that under average flow conditions (about 63,000 cfs) one in every 70 gallons of river water passing Cincinnati had previously been withdrawn and returned by either an upstream municipality or industry. Under drought-flow conditions (such as could be experienced for one month in a 10 year period -- namely 5,400 cfs) the ratio of used water to total flow would be 1 to 6: (1)

Considering the vagaries of quality that distinguish river flow in heavily populated and industrialized areas, one cannot help but marvel at the efficiency of water purification technology in coping with the production of potable supplies from these sources. It is of interest, therefore, to examine what we do know about past and present river-quality conditions.

What We Do Know

Historical records concerning the condition of our rivers and their impact on social welfare are comparatively recent. They date back to shortly before the turn of the century. Their substance reflects primarily subjective value judgments based on the visual and olfactory evidence of sewage and industrial-waste pollution.

Objective measurements of chemical and bacteriological characteristics of rivers during this early period are quite sparse. And those measurements that follow leave much to be desired as a basis for comparative purposes.

Subjective judgments -- Portrayal of early conditions on the Merrimeck in Massachusetts, the Passaic in New Jersey and on waterways in the Chicago and New York areas, offer reasons to assert that progress has been made in curbing quality degradation, at least from the standpoint of gross pollution.

In a 1908 report on the Marrimack (2), the state board of health of Massachusetts concluded that "At present this stream of water is not in a condition to be injurious to the public health..." But it went on to reveal that in many localities, near the outlet of sewers, the river banks were coated with sewage and it reported that the greatest number of complaints stemmed from the discharge of grease in the effluent of wool-scouring mills, which covered both the banks and bud of the stream for long distances. The investigators summed up their findings in this fashion: "...while we cannot say that it (grease) has up to this time been injurious or dangerous to public health, it has become very disagreeable." With regard to corrective measures, the report rather timidly advanced two suggestions. One was that: "It would probably be no great hardship if the scourers of wool were required to keep the grease out of the river." The other suggestion urged that communities give consideration to extending their out-falls into the middle of the stream and thus minimize deposits of sewage on the banks.

In 1896 the governor of New Jersey appointed a commission for the Passaic River to recommend means for correcting nuisences occuring throughout the entire lower valley, due to the river having become, in his words, an "open sewer." (2) It might be noted that the water supply for two major communities -- Newark and Jersey City -- were derived from the lower Passic up until 1892 and 1895 respectively. Your speaker can personally attest to the foulness of the river, which the repository of the uncontrolled waste discharges from some 21 municipalities and a host of industries. My testimony stems from childhood recollections in the 1920's of an occasional ride on an excursion boat that picked up passangers at Newark, N. J. for a trip around New York Bay. Newark is about six miles upstream from the mouth of the Passaic River. And in the 45-minute ride from Newark to the entrance of the bay the stench of what is now recognized as hydrogen sulfide gas, was so overpowering that passengers sought refuge in the cabin during this part of the trip.

Turning to Chicago, we learn from a 1900 sanitary engineering report that one of the waterways traversing the city was so fetid from waste discharges that small animals had no difficulty in running back and forth across its scum-crusted surface. It was aptly named Bubbly Creek.

This is but a sampling of conditions that existed as revealed by subjective viewpoints. Now we turn to what may be gleaned from a more objective or quantitative assessment of the situation.

Objective measurements -- The records of this turn-of-the-century period yield relatively little quantitative appraisal of the chemical and bacteriological characteristics of rivers. And what data is available does not offer information that is easily converted for comparative purposes today.

The measurement of organic nitrogen appears to have dominated the analytical interests of those concerned with river sanitation. In part, at least, this may have stemmed from a two-year study on rivers in Massachusetts sponsored by the State Board of Health and published on 1890 under the title "Pollution and Self-Purification of Streams (2)." The author, F. P. Stearns, said that in making comparisons of sewage-polluted rivers, he concluded that free ammonia, "which formed only in extremely small quantities in unpolluted streams," is the best index. For example, his findings on the Blackstone River showed 2,160 ppm of ammonia at a point shortly below the sewage discharge of a large city, and here the stream was foul and offensive. Some 16 miles downstream, following considerable dilution, the ammonia content was 1.011 ppm; here, said Mr. Stearns, the pollution affected the water quality for industrial uses but it was not "generally offensive" to those living on the banks. Farther downstream where the ammonia content averaged 0.455 ppm the river was declared ineffensive.

Perhaps one of the most definitive chemical and bacteriological reports of its time appeared in the testimony before the U. S. Supreme Court offered by the Chicago Sanitary District in 1900 (2). The State of Missouri sought to restrain Chicago from diverting its untreated sewage into the Mississippi River via a drainage canal that emptied into the Illinois River. The distance traversed from Chicago to St. Louis by this route was about 360 miles and the average time of flow was 18 days.

The Chicago analysts sampled the waterway for its entire length and produced results showing that self-purification reduced the ammonia content, initially 10.90 ppm to 0.46 ppm at the entry to the Mississippi; with respect to bacteria, the initial count of 1,755,000 per cubic centimeter was reduced to 21,000. Missouri based its complaint largely on the potentiality of typhoid bacteria entering St. Louis water intake. It is said that the most important scientific aspect of the Chicago testimony was the data showing the inability of typhoid germs to multiply in river water. Insidently, Missouri lost the case.

Measurement of dissolved oxygen for assessing quality conditions appears not to have received much attention until studies of pollution in New York Harbor were initiated by the Metropolitan Sewerage Commission in 1908 (2). Most of the readings were in the range of 66 to 95 per cent of saturation. In striking contrast as the condition of the mouth of the Passaic River where the best reading was a mere 7 per cent, which confirmed the earlier subjective judgment that this river was indeed an open sewer.

Meantime, New York City commissioned Co. William M. Black, Chief Engineer of the U.S. Army Corps, Department of the East, and Prof. Earl B. Phelps of Columbia University to provide advice on sewage disposal matter. Their reports, presented in 1911 (2), included this statement:

> "The amount of dissolved oxygen in the harbor waters furnished the most satisfactory criterion of the purity of these waters. We believe that this natural purifying agent should not be drawn upon to an extent which will reduce it below 70 per cent of the full saturation value."

This proposed standard, which was referenced primarily to safeguarding fish life, was regarded by George W. Fuller, one of our most astute practitioners in sanitary engineering, as "radical and needlessly severe." Mr. Fuller said: "*...those who have followed these matters most carefully in Europe and this* country feel that 30 per cent is a reasonable margin...and that for some species of fish a residual of 20 per cent is not prejudicial for a limited area around the point of dispersion."

Some 25 years later when the Interstate Sanitation Commission for New York Harbor was created in 1935, the compact (3) stipulated that the highest class of water in the harbor area should be maintained at not less than 50 per cent saturation and that other areas should be at not less than 30 per cent. Thus it would appear that this decision represented a nice compromise between the judgments of Mr. Fuller and those of Messrs. Black and Phelps.

For comparative purposes it can be noted (4) that dissolved oxygen in the Narrows of New York Harbor showed a declining trend in the period 1909 to 1931 from a saturation of 78 per cent to 43. Since then it has moved slowly upward with a value in 1965 of about 62 per cent. During 1975 the average daily saturation varied from a summer low of 42 per cent to a winter high of 100 (5).

Quantitative measurement of river quality conditions has been broadened with the passage of time. With few exceptions, however, the assemblage of data by state and federal agencies is of limited usefulness in discerning trends or for other comparative purposes. The reasons are manifold. They include lack of continuity of record-keeping, changes in the location and frequency of sampling; variations in analytical techniques and failure to correlate quality observations with flow variations. Comparisons are further obscured because the physical and hydrologic regimen of many rivers has been profoundly altered by construction of flood-control impoundments, navigation facilities, irrigation works, hydro-power plants and changes in channel configuration.

Couple this with the impact of changing patterns of land use and we become humbled by the intricacies of diagnosing river quality in the past, relating this to present conditions and in making projections of what the future may hold. Here we are confronted with the classic dilemma of dealing with a dynamic situation within a moving framework of reference.

The Ohio River situation -- One illustration of the nature of the task and efforts to deal with it is to be found in the program of the Ohio River Valley Water Sanitation Commission. This interstate regulatory agency whose acronym is ORSANCO, was created in 1948. Its role is to coordinate the efforts of eight states in placing the waters of the district in a "satisfactory sanitary condition" available for use as a source of public and industrial water supply, suitable for recreational usage and capable of maintaining fish and aquatic life.

Briefly sketched, the situation prevailing in the ORSANCO district is this. The network of waterways includes the 981-mile Ohio River and nineteen major tributaries. These streams serve as the principal source of water for about 13 million people and thousands of industries, and they are also the repository of the wastewaters from these entities. Additionally some of the streams receive the acid drainage from coal mines estimated to be equivalent to the discharge of 1,800,000 tons of sulfuric acid annually, as well as the run-off from extensive and heavily fertilized agricultural pursuits.

With respect to structural changes that have altered the physical and hydrologic regimen of the waterways, there are two of profound influence. On the tributaries some 65 of a projected total of 99 flood-control reservoirs have been built since 1935; one result has been the doubling of dilution water previously available during the summer low-flow periods. Additionally on the main stem since 1929, and earlier on some tributaries, navigation dams have converted these once free flowing waterways into a series of pools or lakes.

Shortly after the pollution control program was inaugurated in 1948, the ORSANCO staff concluded that a clearer understanding of river-quality behavior would require something more than sporadic sampling. It was reasoned that without continuous monitoring and diagnosis of river conditions there could be no suitable basis for evaluating trends and the potentialities for influencing them. These considerations led to the establishment of a monitoring program that had three purposes: (1) to arrange for systematic acquisition of quality data; (2) to interpret the data for judging performance of pollution abatement efforts; and (3) to guide the prescription of additional remedial measures.

From a modest beginning with 11 analytical stations in 1951, the ORSANCO monitor network was gradually expanded. Today it comprises 35 locations where samples are collected manually for analysis, and 21 robot electronic stations where certain quality characteristics are measured hourly every day in the year. These robot monitors were pioneered by ORSANCO and first placed in operation in 1959.

Coupled with these analytical facilities there is a computer center for storage, retrieval and statistical manipulation of data. ORSANCO evaluates water-quality in the Ohio River and its major tributaries using 21 chemical, bacteriological and physical variables. A vital adjunct to all of this is the integration of daily stream flow with the quality data. This was made possible by an arrangement originally with the U. S. Weather Bureau, which has long maintained a flood warning center in the Ohio Valley. At the request of ORSANCO the center elaborated its procedures to provide a daily estimate of flows as well as 3-day forecasts of impending flows at a number of river locations.

ORSANCO publishes a monthly bulletin of data at selected points showing minimum, average and maximum values of quality characteristics as well as their relationship to established river standards. To facilitate interpretation and comparisons there is also included a tabulation of the percentage of time the quality standard was achieved. This bulletin is distributed to several thousand interested parties, including municipal, state, and federal agencies, industries, chambers of commerce and citizen organizations. A more detailed assessment of quality conditions is published annually.

From this substantial array of data, supplemented with periodic intensive surveys of aquatic-life resources, ORSANCO recently (6) offered the following assessment of conditions in the Ohio River.

> Water quality was suitable, after reasonable treatment, as a source of public and industrial water supplies.
>
> Bacterial levels (coliform counts) in some stretches do not meet standards established for body-contact recreation, a condition attributed to the influence of combined and storm sewer discharges as well as urban and rural runoff.
>
> Quality was suitable for the propagation of fish and other aquatic life throughout the 981-miles of river. However, levels of polychlorinated biphenyls and chlordane in catfish, if confirmed, may result in restrictions on commercial fishing and warnings to sport fishermen to limit the amount of catfish eaten.
>
> Model studies predict that with completion of upgraded treatment facilities for all sewage and industrial wastes in accord with 1977 federal effluent requirements, river quality standards for physical and chemical characteristics affected by point source discharges will be met essentially 100 per cent of the time. However, bacterial standards for body contact will not be achieved during the recreational season, and quality characteristics influenced by non-point sources will not change significantly.

Finally, more stringent wastewater control measures to satisfy 1983 federal requirements (best available treatment) will result in only minimal improvement of Ohio River quality.

What We Don't Know

Whatever enthusiasm may be generated by Ohio Valley experiences in advancing the art of river-quality diagnosis and management, the fact is that here, as well as in other river basins, there are aspects of evaluation that command greater attention than has been mustered thus far. Among the most compelling are: assessment of natural versus man-made influences on quality, and the detection and appraisal of toxicity conditions.

Natural influences -- One of the current popular assumptions is that elimination of wastewater discharges should restore waterways to a condition approaching pristing purity. Indeed, this view finds expression in the Federal Water Pollution Control Act, which establishes zero discharge of pollutants as a goal for 1985.

The basis for this misconception reflects the paucity of empirical information on the impact of natural influences on water quality. However, several recent studies have provided clues that suggest the magnitude of this influence. One of the most revealing is the 1973 report of the U.S. Geological Survey on chemical composition of atmospheric precipitation in the Northeastern United States (7). Based on samples collected from 18 relatively uncontaminated sites, it was computed that a total of 2.5 million tons of various chemicals are deposited during a year of average rain and snowfall in this area. It was concluded that essentially all sulfate and nitrogen and much of the chloride and potassium in streams, especially those underlain by rocks that do not tend to dissolve, are supplied by precipitation. The report noted that "knowledge of the chemistry of atmospheric precipitation is an important preliminary to the study of controls on surface and ground water quality."

Efforts also have been made to estimate the organic loading that may be imposed on waterways from natural runoff in forested areas. One made by Rutgers University in New Jersey indicated that this runoff may contribute as much as 50 per cent of the biochemical oxygen demand. The effect of falling leaves was studied by the U. S. Geological Survey on a small stream in Virginia virtually free from cultural pollution where fish became distressed during low-flow periods. The decaying leaves reduced dissolved oxygen to one ppm. And the water color, specific conductance, and content of iron, maganese and bicarbonate all showed peak concentrations at the time of maximun leaf fall, when the pH of the stream was at its lowest point (8).

The relatively recent characterization of sediment as a pollutant connotes a broader appreciation of natural influences on river quality. While activities associated with land use have accelerated, erosion of soil in certain areas, it should be recalled that the Missouri River, for example, gained the title of Big Muddy before man had much impact on its condition. And all rivers become transporters of vast quantities of sediment during periods of flood. The U. S. Geological Survey in Circular 670, reports that the waterways of the United States transport some 492 million tons of sediment annually. This quantity is said to be about 250 times greater than all the solids discharged in wastewater.

Incidently, natural springs issuing into the Arkansas and Red rivers carry 17 tons of salt per minute; springs on the Lower Colorado discharge 1,500 tons of salt daily; and the Lemonade Springs of New Mexico carry 900 pounds of sulfuric acid in every million gallons of discharge (9).

Toxic substances - Turning now to what must be regarded as the most deficient aspect of river quality evaluation is the matter of detection and appraisal of toxicity conditions. Although state pollution control laws have long included a standard prohibition such as "No toxic substances shall be permitted to be discharged into a waterway," neither the drafters of this rule nor those charged with administering it possessed reliable information on what constitutes toxicity. Furthermore, until recently analytical techniques for measuring substances in water suspected to be toxic were relatively crude.

A comprehensive portrayal of these deficiencies and steps being taken to remedy them is contained in a recent report to the Congress, compiled by the Environmental Protection Agency (10). Under the 1974 Safe Drinking Water Act the EPA has the task of ensuring that the nation's drinking water is free of toxic substances. In addressing this task the agency reports that it must, among other things, first determine:

Which compounds occur in a sufficient number of locations and in sufficient quantity to warrant possible regulation;

What are the effects of those compounds on human health; and

What analytical procedures are needed for appropriate monitoring of water quality.

The report points out that only within the last few years have analytical methods sophisticated enough to measure small quantities of contaminents been applied to water. As of November 1975, 253 different organic chemicals in drinking water had been identified, and it is suggested that eventually the total could be considerably larger. Sources of these compounds, some of which have been classified as carcinogens, include industrial and municipal wastewater discharges, urban runoff, natural sources, as well as water and sewage chlorination practices.

Additional monitoring by EPA has included measurement of several inorganic chemicals, radio nuclides and asbestos, all of which are held suspect of being carcinogenic under certain circumstances.

Research is being accelerated to examine health effects. This involves long-term animal studies on the effects of various concentrations of specific contaminants, along with epidemiological investigations seeking to clarify the health risks involved.

A reading of this report makes it abundantly clear that pollution control agencies must gear up their potentialities for monitoring toxic aspects of river quality. Efforts of the Ohio River Valley Water Sanitation Commission to cope with these new quality evaluation necessities have included a research contract with the Carnegie-Mellon laboratory in Pittsburgh to detect, identify and determine the persistance of trace ortanic substances (11). Additionally, one of the new components of periodic assessment of aquatic-life resources in the Ohio River is the analysis of edible portions of fish for evidence of the accumulation of polychlorinated biphynols, (PCB's), pesticides and heavy metals. The analyses conducted by the U. S. Food and Drug Administration laboratory in Cincinnati, reveal that PCB levels exceed the 5 ppm standard at five of eight sampling points on the Ohio River. Although no standards have yet been established for chlordane levels, the FDA expressed concern with the observed levels. The levels for other pesticides and the heavy metals are lower than presently accepted limits (6).

Promise for Improved Performance

Perhaps the greatest promise for improving performance in river quality evaluation lies in the establishment in 1972 of the National Stream Quality Accounting Network (NASQAN) by the U. S. Geological Survey. This undertaking stemmed from issuance of Circular A-67 of the Bureau of the Budget in August 1964. The circular mandated the Geological Survey to design, coordinate and operate a national mechanism for providing data on both the quantity and quality of surface and ground waters (12).

NASQUAN is designed to evaluate quality of the nation's rivers on a systematic and continuing basis. The data base originates primarily from USGS sources, but this input is supplemented with information collected by the EPA, the Corps of Engineers and from some state and local agencies. Presently there 345 monitor stations, ultimately the number will be more than 500.

This undertaking provides for quantitative description of the physical, chemical and biological characteristics of rivers. Three types of reports are to be issued. The first is a collection of basic data on a state-by-state basis. The second type is an annual summary depicting the quality of surface waters, an example of which became available in late 1975. The third type will be devoted to evaluating trends in quality and be issued at 3 to 5 year intervals.

Supplementing this national appraisal, the Geological Survey in 1973 embarked on the first of a series of intensive river-quality assessments. Such a comprehensive study has now been completed for the Willamette River in Oregon, another is underway on the Chattahoochie in Georgia and a third has been initiated on the Yampa River in Colorado. These studies will delineate how quality problems can be identified, assess the effect of waste loadings, hydrology and land use on quality variations, and develop methodology for forecasting future conditions based on alternative development strategies. Details are set forth in Circulars 715-A and B published by the Geological Survey in 1975.

Other developments - There are two other developments that should hasten improvement of performance in river quality evaluation. One of these has been alluded to previously, namely the charge placed on the Environmental Protection Agency by the Safe Drinking Water Act for the appraisal of toxicity conditions.

The other is the effort being made by the federal Council on Environmental Quality to assess conditions and trends for policy and decision-making. The section on water-quality conditions in the 1975 report of the Council (13) summarizes data from a variety of sources and represents a laudable attempt to interpret their significance.

One of these interpretations is based on NASQUAN quality data from 87 stations arranged in a manner to show frequency of violations of aquatic life and drinking water criteria. This composite indicator was used to classify streams in five categories of quality suitability. An improving trend with respect to aquatic life is reflected by the proportion of NASQUAN stations in the "good or fair" catagories, which increased from 61 to 77 per cent between 1961 and 1974. Perhaps even more significantly the proportion of stations in the "very poor and servere" categories dropped from 16 to 3 per cent over the same years.

Improvements in drinking water suitability as measured by this indicator, says the report, are even more pronounced. In 1974, the "good or fair" label could be attached to 92 per cent of these stations as contrasted with 69 per cent in 1961. And the two worst categories, which characterized 10 per cent of the stations in 1961 were reduced to one per cent 1974.

From these and other appraisals of data the Council concludes: "There is growing evidence that some of our worst water quality problems have been diminishing." But it also points out that "...nutrients, trace metals and land runoff are going to present difficult and persistant challenges to the national commitment to improving water quality."

To sum up: This sketch of early attempts to assess river-quality conditions and the steps leading to current programs for this purpose provides perspective on the elusiveness of the task and magnitude of effort required to cope with this basic component of water resources management. However, new diagnostic techniques are being fashioned and there is a good promise that their application will provide a more definitive basis for decisions, particularly with respect to the re-use of water.

REFERENCES

(1) Cleary, E.J., Horton, R.K., and Boes, R.J. "Reuse of Ohio River Water" Jour AWWA vol. 55, no. 6 June 1963 pp. 683-686

(2) Fuller, George W. Sewage Disposal, McGraw-Hill Book Co., 1912

(3) Interstate Sanitation Commission Compact Public Res. No. 62 74th Cong. 1st Sess., approved Aug. 27, 1935.

(4) Wolman, M. Gordon, "The Nation's Rivers", Science vol. 174 Nov. 26, 1971 pp. 905-918.

(5) Interstate Sanitation Commission, Annual Report 1975

(6) Ohio River Valley Water Sanitation Commission "Assessment of 1975 and Future Water Quality Conditions - Ohio River Main Stem" March 1976.

(7) U. S. Geological Survey, "Chemical Composition of Atmosphere Precipitation in the Northeastern United States," Water Supply Paper 1535-P 1973.

(8) Anon. "Water Pollution from Falling Leaves Studied" Water Control News No. 44, Mar. 1963 pp 17-18.

(9) Pecora, William T. Commencement address, George Washington University Washington, D.C. Abstract in Indus Water Engineering Aug. 1970 p. 6

(10) Report to Congress, "Preliminary Assessment of Suspected Carcinogene in Drinking Water" U.S. Environmental Protection Agency, Washington, D.C. Dec. 1975.

(11) Ohio River Valley Water Sanitation Commission, Annual Report, 1974 p. 20

(12) Ficke, J. F. and Hawkinson, R. O. The National Stream Quality Accounting Network, U.S. Geological Survey Circ. 719 Washington, D.C. 1975

(13) Council on Environmental Quality, Sixth Annual Report Dec. 1975 pp. 348-400

SUMMARY OF EUROPEAN METHODS OF RIVER TREATMENT AND RE-USE

By

Franklin Dryden - Chief of Technical Services
Sanitation Districts of Los Angeles County

Presented at the Third Annual Conference, WATERCARE
"Conservation Through Reclamation", June 10-11, 1976,
Pepperdine University, Malibu Campus.

SUMMARY OF EUROPEAN METHOD OF RIVER TREATMENT AND REUSE*

By Franklin D. Dryden[1]

INTRODUCTION

It was the intention of the Committee that planned this Conference to obtain a speaker from Europe who could present an authoritative report on river management systems in that part of the world. However, since the Conference budget precluded bringing someone over and I was unsuccessful in locating a resident expert, I have been left with the task of sharing my rather limited knowledge of the subject with you. I at least had the opportunity to visit the Ruhr River Valley in 1962, and have supplemented that experience with a more current review of the literature and communications with Professor Muller of West Germany and Dr. Packham from England.

WATER MANAGEMENT IN THE RUHR RIVER VALLEY, GERMANY

As shown in Figure 1, the Ruhr River Valley encompasses the Ruhr River and its tributaries, which ultimately discharge to the Rhine River. The main channel of the Ruhr is approximately 170 kilometers and serves a total population of about 5 million people with a significant amount of industrial development. The city of Essen, about 45 kilometers from the mouth of the river, is perhaps typical of a large city in the Ruhr Valley in that it derives most of its water supply from the Ruhr River and treats the water through a natural soil filtration system. In 1962, the city of Essen operated approximately 50 acres of filter beds and produced 55 mgd of water for a population of about 750,000. Without the filter beds, the underlying aquifers would generate about 8 mgd of flow. The system utilized is illustrated in Figure 2. The water system takes advantage of a natural sand strata 20 to 40 feet in thickness, which rests on a bed of sandstone slate and is overlain by a clay cap. The filters are established by excavating the clay overburden down to the top of the natural sands and covering the bottom of the excavation with a 50-centimeter thick layer of coarse sand. The water passes vertically into the natural sand strata and then horizontally a distance of about 150 feet to collection galleries or wells, which remove the water for delivery to the city mains. Infiltration rates are relatively high, averaging three to five vertical feet per day over the filter area. Each filter bed operates for a period of approximately three months before it is taken out of service, and the organic layer, or *schmutzdeche*, is dried and removed. When I observed the operation in 1962, the removal was performed by hand labor, and the entire water plant was operated by approximately twenty people.

---

*WATERCARE Annual Conference, "Conservation Through Reclamation" at Pepperdine University, Thursday, June 10, 1976.

[1]Head, Technical Services Department, Sanitation Districts of Los Angeles County

In order to extend the length of filter runs, some communities utilize high rate prefilters ahead of the recharge basins. The prefilters are shallower but otherwise somewhat similar in design to the main filter beds. They are often followed by cascade aeration, which is simply a series of broad-crested weirs, with a short fall into a shallow pool at the top of the next weir. Cascade aeration is used to raise the dissolved oxygen content and reduce the carbon dioxide concentration and temperature of the water before it enters the main filter beds. The higher D.O. levels assist in keeping the filter beds aerobic.

THE EFFECT OF DROUGHTS

The development of the water management system in the Ruhr River Valley is directly related to droughts. A severe drought in 1911 literally dried up the river. The discharges from wastewater treatment plants simply percolated into the gravel of the riverbeds and were withdrawn from wells downstream. Although there may have been some subterranean flow that was not counted in the calculations, the 1911 drought resulted in 100% reuse. That means that the total discharge from wastewater treatment plants equaled the total flow in the river. This severe drought led to the formation of the Ruhr River Board in 1913. In order to protect against future droughts, the River Board commenced building storage reservoirs. However, when the next major drought occurred in 1929, storage facilities were still inadequate and water consumption had increased. Reports of this period in the literature indicate that a reuse factor of 300% occurred. Although such a reuse factor indicates that the total flow of the river was used three times, its meaning is difficult to interpret. The literature reports that water was actually pumped upstream from the Rhine over the low control dam to provide for additional makeup flow during the drought. It is not clear how this supplemental flow entered into the reuse calculation. The literature indicates that, during this period of drought in 1929, no problems of public health were noted in Essen or the other communities obtaining water supplies from the Ruhr.

The 1929 drought again emphasized the need to provide more reservoirs for low flow augmentation. Generally, most of the rainfall of the Ruhr occurs during two-thirds of the year, leaving about 140 days when flows become quite low. The water management plan projects a reuse factor during the low flow period of about 22%. However, in 1959, another drought occurred during a period when reservoir capacity was still inadequate. A major new reservoir was still under construction and a large old reservoir had to be taken out of service for repair of damage that had occurred in World War II. Through the summer of 1959, the reuse factor began increasing until by December it had reached 86% in the city of Essen. This high reuse factor was substantiated by measurement of the hard surfactant, alkyl benzene sulfonate (ABS), which reached concentrations of 4 to 5 mg/l in the river. Although ABS was believed to be nonbiodegradable, concentrations in the treated water only reached 1.2 mg/l by the methylene blue active substances (MBAS). Incidentally, at the point where the river water flowed over the low water level control dike, the foaming of the ABS resulted in a stable mound of foam over 20 feet deep, which they referred to as their "iceberg". Cold temperatures in December also stopped the nitrification of ammonia, and ammonia concentrations became detectable in the treated water. The most significant health effect observed during this period was that 5% to 10% of the population of the city of Essen reported cases of nonbacterial gastroenteritis or stomach upset. Health authorities theorized at the time that the gastroenteritis may have been due to the ABS, but there appears to have been insufficient data to establish whether ABS or some combinations of other materials were the cause. Although no data were available in the literature on COD or other gross measures of organic content, it is reasonable to assume that an MBAS concentration of 1.2 mg/l in the water supply would be accompanied by a significant COD. There were of course increases in chlorides and other mineral constituents that aren't relevant to this paper. From a bacterial standpoint, the filter system continued to perform effectively. Total coliform counts of 20,000 to 30,000 per ml in river water were reduced to 10 per ml in drinking water, and E-coli concentrations of 200 to 600 per ml were reduced to zero.

The high degree of reuse in 1959 did not result in detectable health problems until after the reuse factor reached 65%. Allowing for a suitable safety factor, the Ruhr River Board anticipates that future periods of low flow will not experience a reuse factor of over 22%, and reuse will average about 7.5% under normal conditions. These levels are considered acceptable from a public health standpoint.

ENGLISH PRACTICE

Some limited information through personal contacts and literature reviews were obtained on reuse factors in Great Britain. Two-thirds of the water supply of London comes from the Thames River where the average reuse factor is estimated to be 14%. The Great Ouse River in England is being reused at a rate of 40%, with projections that it will increase substantially in the years ahead. In fact, English authorities have proposed a limit of 75% for the reuse factor on water supplies derived from rivers. England has generally had a plentiful water supply and has not spent a great deal of effort in the past working on reuse problems. The current recognition of high reuse factors has lead to proposals to conduct additional research on public health factors similar to those proposed in the United States.

SUMMARY

The European practice of obtaining water supplies from river systems that receive municipal and industrial waste is similar to that of the United States. To date, relatively little research work has been conducted on potential long-range health effects and, in only one case in Essen, did a high level of reuse result in clinically detected symptoms. Although the Europeans have no more knowledge than the Americans concerning the appropriateness of the safety factor, their tentative recycle limits appear to be somewhat higher than those being contemplated in the United States. It appears that the European approach is more inclined to continue present practice until research provides reasons to do otherwise, rather than to set standards that would preclude reuse based solely on the theorized possibility that unknown organics may contribute to chronic health effects.

At the present time, our state of knowledge is very limited. We often know that a particular organic chemical may be carcinogenic or toxic at relatively high concentrations. We don't know whether a very slight dose of the same material over a long time will cause the same problem. Chloroform, for example, was cited in the New Orleans study as a probable cause of bladder cancer. However, it has recently been reported that about 100,000 lbs. of chloroform are ingested by Americans each year, primarily in cough medicines, and another 100,000 lbs. of chloroform are inhaled each year. The persons using these products receive much higher doses than the population in New Orleans, or anyone whose chloroform intake is presently limited to that which occurs in water supplies. Only very careful epidemiological and scientific study will permit us to discern the real problems from those that are hypothesized from circumstantial evidence. In Europe, the tendency appears to be to proceed with the practices that have been acceptable in the past until new data show that they should do otherwise. In the United States, we are more inclined to hold up all water reuse while waiting for technical data to show it is okay to proceed.

QUESTIONS AND ANSWERS

Question: What is the basis in England for setting a limit of 75%?

Answer: I don't know precisely - I think it's partly based on their experience in some of their rivers, and perhaps, some of the experience in Germany. It's an arbitrary figure at this point. They would admit they don't have enough data to precisely define what it ought to be.

Question: (Seems to be a comment - Mr. Dryden repeating the comment.)

Answer: Mr. Warne indicates that, when he met in Brussels with the economic group there, it was reported that they are placing their more stringent restrictions on the agency that diverts water from the river for use so that, before they deliver it to the community, they must provide a higher degree of treatment. It may mean, in some cases, uses of demineralization by reverse osmosis; or they might have to add activated carbon in certain situations. They're treating the water to a high degree just before they deliver rather than before they put it into the river.

Question: Did they use ozone to get rid of organic matter?

Answer: First, in speaking about the Ruhr situation - as far as I know, they were not ozonating or chlorinating it, but the filter provided the bacterial protection that they felt they needed. Yes, ozone does, in fact, help destroy organic matter and, to some degree, so does chlorine.

Question: Some years ago, I remember reading that, in the Ruhr, there was another river that was used as an open sewer, and the water management agency was exactly that - very heavily into management.

Answer: They have organized their river basins from a water management standpoint where all of the wastewater and the water supply is essentially controlled by the same board, and that permits them to make those kinds of choices on the most economic, environmentally sound, or whatever other factors they wish to consider, basis.

Question: What is the per capita water consumption in Europe, and what water conservation practices have been adopted?

Answer: Well first, per capita usage in Europe has generally been lower than in the United States; I believe about 150 liters per capita per day - which is about 40 to 50 gallons. I've no knowledge as to precisely what kind of water conservation practices were employed during the drought, but I'm confident that people did what they could. In Europe, you'll find that many of their toilets and other appliances incorporate low water use systems compared with ours, which use larger quantities of water.

Question: I would just like to supplement your data with information on the Ohio River and reuse factors there. Reuse at the one month in ten years drought flow on the Ohio River would be 16% at Cincinnati. If we take one of the major tributaries on the Monongahela, the reuse up there is over 40%. I've forgotten what the reuse factor was at Chanute, Kansas, but the water was recycled from treatment plant effluent several times. I might say that I have spent a little time on the Ruhr and Dr. Imhoff once told me that, in his opinion, seven times reuse would be appropriate; beyond that, the salt content gets too high and it would not be very usable water. Incidentally, on the Rhine, where it passes through Dusseldorf, the water is so salty - it's way over 1,000 - that few people can drink it. They have no means of removing the salt and that's what is causing such a problem in Holland where this very salty water originating in the potash mines in France ends up. The Rhine River Commission has been attempting over the last twenty years to solve the problem. They have gone so far as the Netherlands government offering to pay the French mines half of the cost of removing this salt - which of course damages the entire Rhine River all the way down to the border in Holland.

Ruhr River Valley

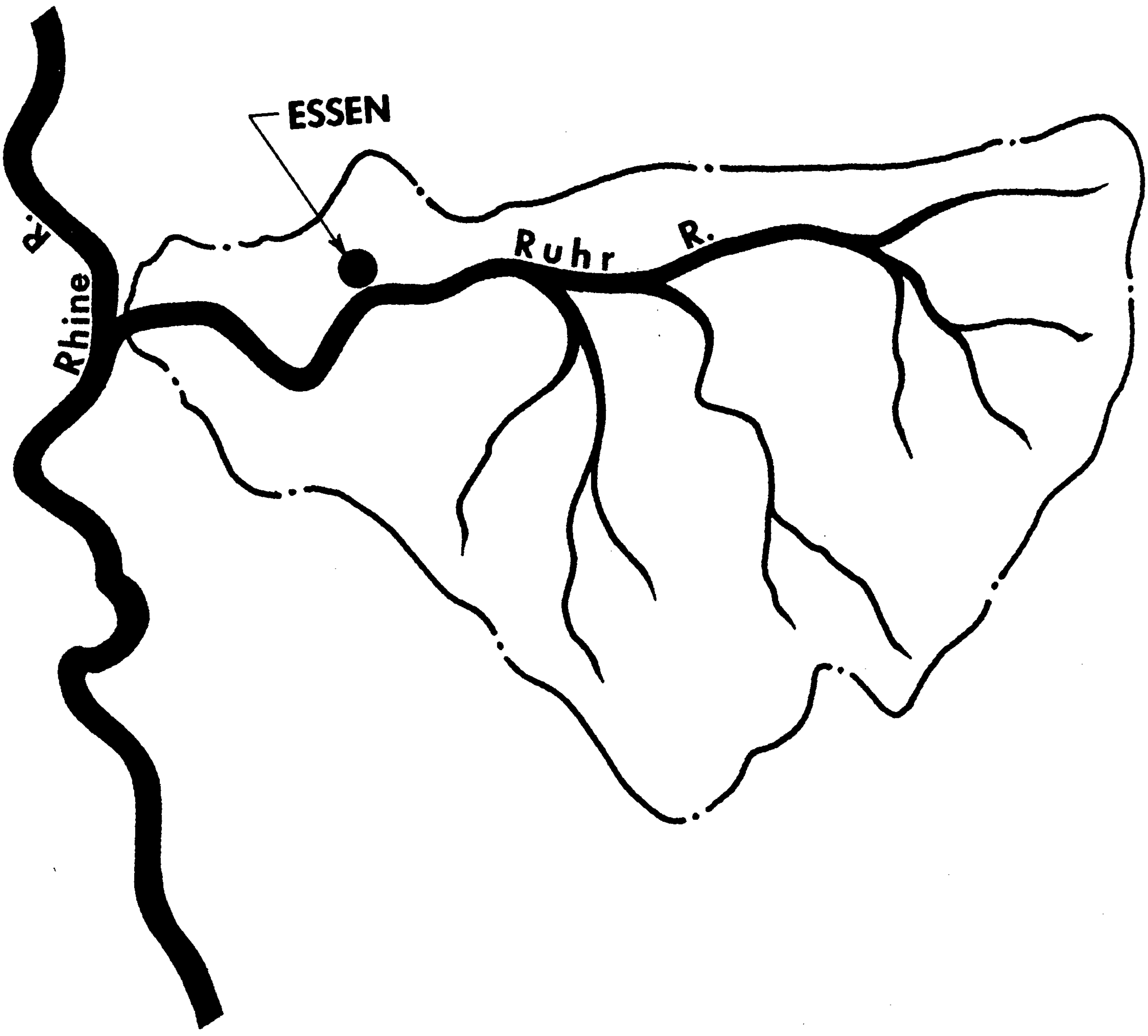


FIGURE 1

Essen Water Supply

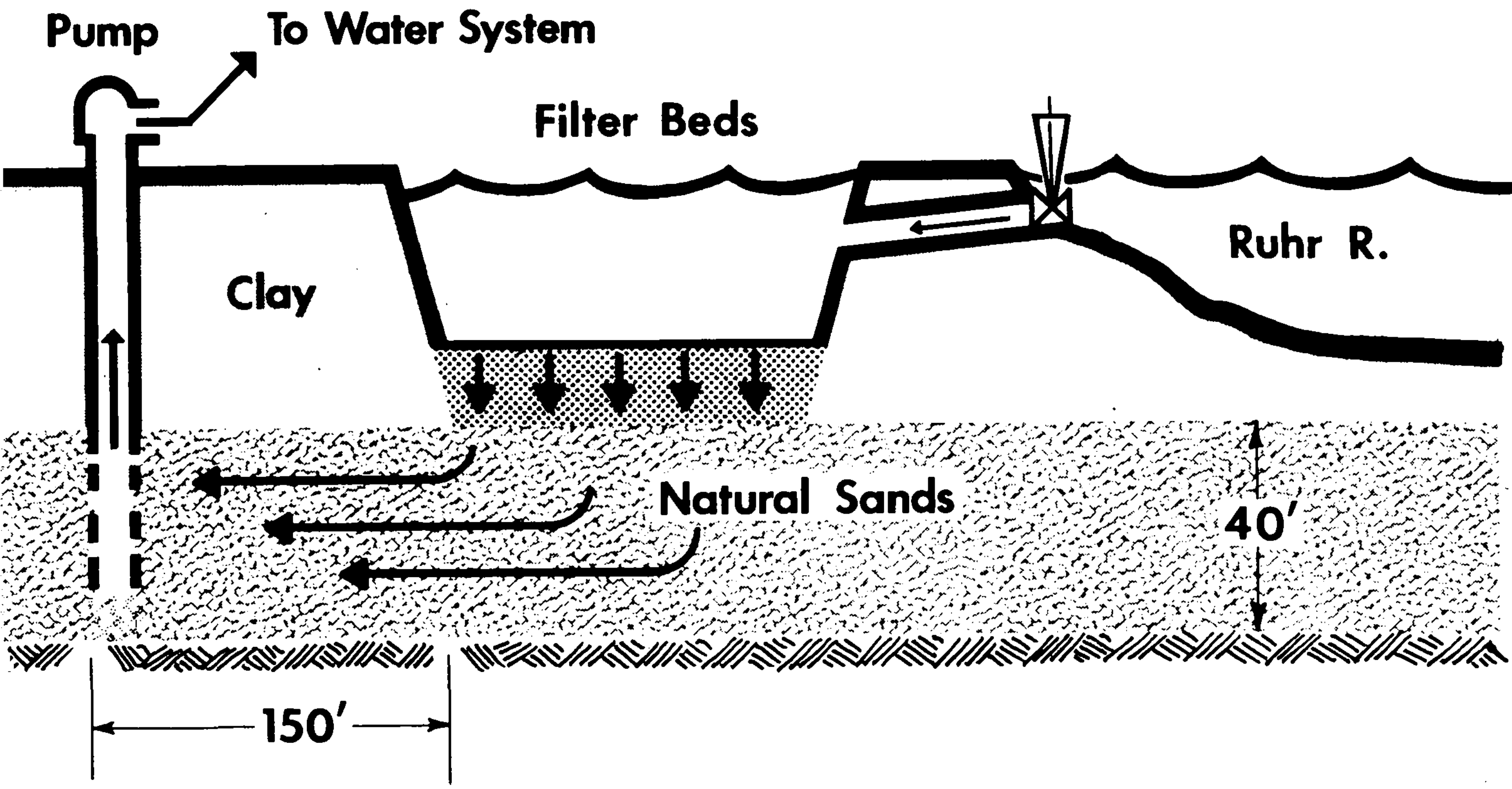


FIGURE 2

WINDHOECK SOUTH AFRICA'S WATER TREATMENT AND RE-USE

By

William Seeger - Kennedy Engineers

Presented at the Third Annual Conference, WATERCARE
"Conservation Through Reclamation", June 10-11, 1976,
Pepperdine University, Malibu Campus.

PRESENTATION AT WATERCARE'S THIRD ANNUAL CONFERENCE
JUNE 9-11, 1976
WINDHOECK SOUTH AFRICA'S WATER TREATMENT AND REUSE

BY WILLIAM R. SEEGER
KENNEDY ENGINEERS, INC.

When I was asked to arrange for a presentation on the Windhoeck situation, I wrote to the Director of the Institute and asked if it were possible that someone from their organization would be in the area at the time of your meeting. He replied to my letter, indicating that no one was going to be here, but sent along several of their recent publications and suggested that one of these might be desirable for our purpose. -- I intend to read to you a paper titled, " A Case for Reclamation" by Dr. C. G. Cillie, who is Director of the Institute and Dr. G. J. Stander, who is on the Water Research Commission.

Last year I spent three weeks in Africa on a photographic safari and fortunately a day's layover was scheduled for Johannesburg. I took this opportunity to spend the day at the headquarters of the National Institute for Water Research of the South African CSIR which are located in Pretoria, the legislative headquarters of the South African government.

South Africa has a rather unusual governmental structure which was brought about by the fact that when the five separate countries merged into the Republic of South Africa, there was the question as to where the capitol should be. Due to the political situation involved, it became apparent that they could not obtain majority votes for one location and therfore reached a compromise position which provided for two seats of government. The first was called the legislative branch of government, which is located in Cape Town and the second designated as the administrative division of government is located in Pretoria. Therefore the legislature meets for six months in Cape Town during which time the legislation is developed and passed and then the legislators move to Pretoria from where they administer the legislation.

I feel that it is important for you to know and understand just how the Republic of South Africa has been able to make the tremendous strides that they have in the field of wastewater reclamation. Their accomplishments are due to two governmental organizations. The first is the "Council for Scientific and Industrial Research" and the second is the "National Institute for Water Research". I believe, to the best of my knowledge, South Africa is the only country that has a full-scale research program sponsored by the federal government. England has a very outstanding water research laboratory and we in the United States, while we have been attempting to promote this type of program at the federal level, have been unsuccessful. Our closest approach to it is the recently organized American Water Works Association's Research Foundation, which Watercare is working with relative to research on wastewater reuse. Due to the unusual circumstances, I felt that it would be interesting to give you a short background of each of these organizations. I'm only going to give the highlights at this time, due to the limit of time but more detail is given in the paper.

COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

Introduction

The Council for Scientific and Industrial Research (CSIR) was established in 1945 as a corporate body. Its statutory functions are to undertake and also promote scientific and industrial research in the Republic of South Africa, to advise the Minister on scientific and technological matters affecting the utilization of the natural resources of the Republic, on the development of its industries, and on the proper coordination and employment of scientific research to these ends, and to cooperate with educational authorities and other organizations in the teaching of science and the training of research workers and technologists.

Aims

The CSIR's aims can be divided into four main categories, namely:

the development of human resources, inter alia basic research (whether projects in the CSIR's own laboratories, support of university researcy or national research programs linked with international programes) for the training and development of research staff; personnel research, training of technicians and research into educational techniques, facilities and buildings; international liaison; library and information services.

the development of material resources (industrial production), inter alia the study of technological innovation as a factor in industrial development and economic growth; the promotion of industrial research; research projects in the CSIR's own laboratories on behalf of various industrial sectors; services in connection with production technology

the development of community services (local and regional), inter alia where there is a need for coordinated research as a basis for planning regional development; research into urban development including housing schemes, removal of waste products and prevention of air pollution; research into the design of hospitals and other special buildings as well as nutrition and use of water

the development of national services inter alia investigation into the need for research for the development of an infra-structure for economic progress; research into roads, road transport and rail transport, harbors and sea transport, air transport, pipelines and communications.

Organization

National research laboratories, institutes, groups and units

The Council has 15 national research laboratories and institutes. The head-quarters and most of the laboratories are located at Scientia, the Council's research center 11 km east of Church Square, Pretoria. The National Institute for Telecommunications Research and the National Institute for Personnel Research are housed on the campus of the University of the Witwatersrand in Johannesburg, while the National Research Institute for Oceanology is situated on a site adjacent to the University of Stellenbosch, and the South African Wool and Textile Research Institute is situated on a site adjacent to the University of Port Elizabeth. The South African Astronomical Observatory in Cape Town (with national institute status) and the Magnetic Observatory at Hermanus (Cape) are also part of the CSIR organization. In addition, about 22 CSIR grant-supported research units have been established at various universities.

Research-related activities

Scientific and technical information: As the principal scientific organization in the Republic, the CSIR has specific responsibilities for the collection, storage, retrieval and dissemination of scientific and technical information. The central responsibility for this function is vested in the CSIR's Scientific and technical Information Group as part of the internal STI network, and services tailored to the interests of users in specific fields are provided by national research laboratories, institutes and units as a corollary to their other functions.

Publishing, publicity and liaison: The results of research undertaken by or supported by the CSIR, are normally published in local and overseas scientific and technical journals. However, publications catering for particular interests are published by the CSIR's reasearch establishments, editorial and publishing services being provided by a central Publishing Division. All these publications are listed in a quarterly bibliography, CISR Publications, and are available from the Distributor of Publications, CSIR, P.O. Box 395, Pretoria 0001. Contact with the mass media, i.e. the press, radio and television, technical and trade journals, is maintained by a central Publicity Division, which is responsible for developing expertise in all modern means of communication.

The organization of conferences, symposia and seminars in association with other research organizations and scientific and technical associations is a major commitment of a Conference and Liaison Group which also handles arrangements for visitors to the CSIR, participation in exhibitions and special functions.

Assisted by an Advisory Committee on Internation Cooperation in Science (ACICS), the CSIR, through its International Relations Division, discharges its responsibility for maintaining the Republic's international relations in science -- which includes maintaining offices in Bonn, London, Paris, Teheran and Washington as well as membership of non-governmental international scientific organizations.

Development and Coordination of Research

In addition to research programs and projects undertaken by the CSIR itself, financed from an annual parliamentary grant or with sponsorship from public and private organizations, a major function of the Council is to promote the development of research in the country generally -- in those fields for which it has particular responsibilities.

University research: For the promotion of research activities in the universities and museums, grants are made annually on the basis of applications from individual research workers, units and groups at the universities and museums, as well as for overseas study. Current expenditure under this heading amounts to about R 1 742 800 (1975/76). In the discharge of this important function, the CSIR is assisted by a Research Awards Committee with subcommittees for all the major disciplines in the natural sciences and engineering, on which academic staff of the various universities serve in rotation.

National scientific programs: In contrast to ad hoc university research grants, for which the sole criteria are the abilities and initiatives of the applicants (as adjudged by their peers), national scientific programs of scientific research and observation, often associated with internation endeavors, are organized by the CSIR in collaboration with official agencies, universities and laboratories in the private sector. These coordinated efforts are normally aimed at the elucidation of natural phenomena of world-wide scientific interest and importance which, on account of their magnitude and complexity, are unlikely to be solved by separate organizations, or even nations, working alone.

These programs are developed, coordinated and administered by the CSIR's National Scientific Programs Unit under the guidance of national committees.

Industrial research: Assisted by an Advisory Committee for the Development of Research for Industry (ACDRI) the CSIR, through its Industrial Research and Development Group, continually reviews the technological needs as well as the more effective deployment of research and development, improved means of achieving technology transfer, and increasing the innovation potential of South Africa's manufacturing industries. In addition to ad hoc projects undertaken by the CSIR itself, under contract to industrial firms, continuing programs of research related to sectors or subsectors of industry are sponsored by associations or firms. Three industrial research institutes, serving the fishing, leather and the sugar milling industries, set up as companies not for profit, are financially supported by the CSIR on a pro rata basis.

Information and technical services to assist, in particular, small and medium-sized firms in the application of known techniques tailored to their particular requirements, are made available from CSIR research institutes, laboratories and other services on a coordinated basis through the CSIR's Automation and Production Technology Services.

Supporting Services

Specialized service departments cater for financial and staff administration, technical services such as instrumentation and related development and maintenance, and buildings and site services.

Finances and Staff

The Council's major source of funds is an annual grant voted by Parliment and paid by the Treasury via the Department of Planning and the Environment. In addition, its work is supported financially by grants-in-aid from other government agencies, provincial administrations and other organizations, and it also derives a substantial income from contract work carried out in its laboratories for industrial and other organizations.

The total staff establishment (scientific, technical and administrative, as well as support staff) numbers approximately 4445.

Divisions of CSIR

The CSIR is subdivided into 19 operating divisions, viz:

Chemical Research	Road Research
Physical Research	Water Research
Mathematical Sciences	Electrical Engineering
Astronomy	Oceanology
Telecommunications Research	Mechanical Engineering

Building Research
Food Research
Personnel Research
Wool and Textile Research
Defense Research
Geomagnetism
Timber Research
Chemical Engineering
Air Pollution Research

The responsibility and brief description of the work undertaken in each of the above categories is as follows.

Chemical Research Total staff: 139

National Chemical Research Laboratory

The National Chemical Research Laboratory serves as a center where the latest developments in chemical science are brought to bear on problems of national significance.

In accordance with a policy of concentrating on research in fields where a demand for more basic knowledge exists, many of its reasearch projects are carried out in collaboration with research organizations that are more directly concerned with the practical problems involved. Long-term, well-motivated problems are therefore approached from a fundamental point of view.

Analytical Chemistry Division

Corrosion Research Division

Molecular Biochemistry Division

Physical Chemistry Division

Western Cape Regional Laboratory --

Corrosion Research Division

Biological Chemistry Division

Inorganic Chemistry Division

Organic Chemistry Division

Chemical Defence Unit

Administration

Physical Research   Total staff: 197

National Physical Research Laboratory

The NPRL is subdivided into four main groups, namely the Applied Physics Group, Earth Physics Group, Materials Sciences Group and Nuclear Sciences Group, each consisting of a number of key groups of specialized researchers.

Applied Physics Group

- Optical Sciences Division
- Physical Acoutics Division
- Precise Physical Measurements Division

Earth Physics Group

- Atmospheric Physics Division
- Geochronology Division
- Geophysics Division
- Natural Isotopes Division

Material Sciences Group

- Applied Spectroscopy
- Crystallography Division
- Director's Laboratory
- Electron Microscopy Division
- High Pressure Physics Division
- Physics of Materials Division

Nuclear Sciences Group.

Mathematical Sciences Total staff: 107

The research of the National Research Institute for Mathematical Sciences, established in 1961, covers various branches of mathematics and their application. The Institute participates in the development of theory and the planning and interpretation of experiments. It does basic research and renders services to industry, government and other organizations.

Mathematics Division	Operations Research Division
Computing Center Division	Technical Information
Computer Science Division	Administration
Statistics Division	

Astronomy Total Staff: 78

South African Astronomical Observatory Astronomical staff: 21

The South African Astronomical Observatory (SAAO) came into operation on 1st January 1972. It was formed by merging the former Royal Cape Observatory which was founded in 1920 as a southern station of the Royal Greenwich Observatory, and the former Republic Observatory in Johannesburg, which was founded in 1903 as the Transvaal Observatory. There is a newly-built observing station at Southerland, Cape Province.

Telecommunications Research

National Institute for Telecommunications Research Total staff: 301

The National Institute for Telecommunications Research (then the Telecommunications Research Laboratory) was established under the CSIR in 1946 to investigate problems in radio and radar in some way unique to Southern Africa. Its work is guided by the Telecommunications Advisory Committee under the chairmanship of the Deputy President of the CSIR.

Radio Space Research Station Administration

French Tracking Station

Road Research

National Institute for Road Research Total staff: 214

The research program of the National Institute for Road Research (NIRR) is aimed primarily at finding practical solutions to a wide spectrum of problems concerning transportation, road construction and road safety. In the field of transportation, attention is given to transportation planning, area traffic control, public transport, and the cost structure of certain modes of transportation. In the field of road construction studies are made of road materials (natural and treated with cement or bitumen), earch structures (such as cuttings, fills and tunnels), pavement design and maintenance procedures. Techniques and apparatus are developed to control construction processes. Road safety research includes the statistical quantification of the road safety situation, measurement of the effectiveness of measures applied to improve safety, road user aspects (such as pedestrian behavior, law enforcement and accident case studies), and aspects of roads and traffic related to safety. The Institute works in close association with the national and provincial road authorities, the South African Railways, the National Road Safety Council, industry, the South West Africa Administration and the Rhodesian Ministry of Roads and Road Traffic. These authorities provide the largest proportion of the Institute's research funds.

Research Application and Information Group

Administration

National Data Bank for Roads

Research

Transportation Group

Materials and Design Branch

Soil Engineering Group

Pavement Engineering Group

Treated Materials Group

Maintenance and Construction Group

Road Safety Branch

System Analysis Group

Road and Traffic Factors Group

Road Users Group

Water Research

National Institute for Water Research   Total staff: 176

The National Institute for Water Research (NIWR) became an independent institute of the CSIR on 1st April 1958. Prior to that it was the Water Research Division of the National Chemical Research Laboratory, which was established in 1948.

Freshwater Biology Division

Water Quality Division

Biotechnology Division

Physico-chemical Technology Division

Technological Application Division

Mineralized Waters Division

Natal Regional Laboratory

Cape Regional Laboratory

South West Africa Regional Laboratory

Orange Free State Regional Laboratory

Electrical Engineering

National Electric Engineering Research Institute Total staff: 153

The work of the National Electrical Engineering Research Institute (NEERI) covers the various fields of both heavy and light current electrical engineering.

Automation Division

Solid State Electronics Division

Applied Electronics Division

Electronic Instrumentation Division

Training and Information Division

Power Electrical Engineering Division

Signal Processing Division

Administration

Oceanology

National Research Institute for Oceanology Total staff: 107

The National Research Institute for Oceanology(NRIO) was established in 1974 to take over and merge preexisting CSIR activities in marine science and technology, and to provide appropriate professional, technical and logistic advice, assistance and support to all South African and foreign organizations as required for their work in the coastal and oceanic areas adjacent to South Africa.

Marine Geoscience

Chemical Oceanography

Marine Biology

Coastal Engineering and Hydraulics

Physical Oceanography

National/International Cooperation

Special Facilities and Services

Administration

Mechanical Engineering

National Mechanical Engineering Research Institute Total staff: 181

The National Mechanical Engineering Research Institute (NMERI) is concerned mainly with the development of new ideas and techniques in mechanical engineering as well as the improvement of machines and materials used in industry. The Institute is also active in fields such as geomechanics, which is of importance in civil engineering. In addition the Institute has testing equipment and machines, instruments and qualified personnel for research in the fields of metallurgy, strength of structures, process development, goemechanics, fluid mechanics and heat mechanics (including air-conditioning and refrigeration.

Metal Mechanics Division

Strength Mechanics Division

Geomechanics Division

Process Mechanics Division

Fluid Mechanics Division

Heat Mechanics Division

Aeronautics Research Unit

Mine Equipment Research Unit

Technical Information Division

Administration

Building Research

National Building Research Institute   Total staff: 227

The National Building Research Institute (NBRI) was established in 1945 to carry out research, both fundamental and applied, into all aspects of building. Since investment in building and construction in South Africa is now approximately R 3 000 million per annum, the cost of erection and maintenance of buildings and other structures are vital factors in the nation's economy. The NBRI's function is to serve the needs of this vast industry, which are constantly changing as technological advances result in new materials and methods of construction. This calls for research into building design, structural and foundation engineering, fire, plumbing and sewerage, the behavior and improvement of building materials, lighting, ventilation and acoustics, building economics, management, industrialization and many other aspects of building -- all with a view to the more efficient erection of better buildings.

Administration
Architectural Division
Building Research Application Division
Building Services Division
Environmental Engineering Division
Evaluations and Performance Criterial Division
Fire and Concrete Engineering Division
Geotechnics Division
Inorganic Materials Division
Methods and Applied Economics Division
Organic Materials Division
Structural Engineering Division

Food Research

National Food Research Institute   Total staff: 148

The main aim of the National Food Research Institute (NFRI) is to promote effective utilization of South Africa's food resources. Its activities include both fundamental and applied research into aspects of food composition, utilization, preservation, packaging and storage, as well as product and process development.

Food Chemistry Division
Food Technology Division
Biological Evaluation Division
Techno-economics Division
Microbiology Research Group
Bantu Beer Unit
Administration

Personnel Research

National Institute for Personnel Research   Total staff: 143

Management Studies Division
Personnel Selection and Vocational Guidance Divisions
Training Studies
Psychometric Division
Temperament and Personality Research Division
Industrial Ethnology Division
Neurophychology Division
Sensory-motor Studies Division
Computer Services Division

Wool and Textile Research

South African Wool and Textile Research Institute   Total staff: 118

Investigates the physical properties of fibers, yarns and fabrics and their influence on mechanical processing and end commodity consumption.
Protein Chemistry Division

Cotton Chemistry and Finishing Division

Dyeing and Finishing Division

Scouring Division

Textile Physics Division

Statistics Division

Testing Services

Carding and Combing Division

Drawing and Spinning Division

Knitting Technology Division

Weaving Division

Cotton Processing

Publications

Machine Development Division

Workshop

Administration

CSIR Regional Office

Defence Research

National Institute for Defence Research

The National Institute for Defence Research (NIDR) was established on 1 October 1963, in response to the need for systematic planned research on behalf of the Department of Defence and to enable it to keep abreast of the rapid scientific and technological developments in this field.

Research and Development Department

Propulsion Division

Missiles Department

Engineering Services Department

Administration

Geomagnetism

Magnetic Observatory   Total staff: 18

The Hermanus Magnetic Observatory joined the ranks of the CSIR as a research unit in April 1969. It was founded by the late Dr. Alexander Ogg and functioned under the auspices of the University of Cape Town until 1937, and subsequently under the Trigonometrical Survey Office of the Department of Lands from 1937 to 1969. The Observatory was transferred from Cape Town to Hermanus towards the end of 1940.

Timber Research

Timber Research Unit   Total staff: 60

Timber Engineering Division

Timber Economics Division

Wood Processing Division

Pulp and Paper Division

Information and Liaison Services Division

Special Projects

Administration

Chemical Engineering

Chemical Engineering Research Group   Total staff: 60

Nature of Research: Studies in particle technology and particularly slurry technology; mechanisms and effects of flocculation; filtration and other dewatering techniques; cake washing; particle separation according to size; reactor technology; air pollution control engineering. Studies of the mechanism of depolarization in dry batteries by manganese dioxide. Fundamental investigations into physico-chemical surface pheonomena and into mass and heat transfer problems.

Air Pollution Research

Air Pollution Research Group — Total staff: 17

The Air Pollution Research Group was inaugurated in 1961 as an inter-disciplinary facility to determine the extent of air pollution and to combat it by giving advice on control measures.

Chemical Analysis

Dispersion Studies

City Atmospheres

NATIONAL INSTITUTE FOR WATER RESEARCH

The National Institute for Water Research (NIWR) became an independent institute of CSIR on April 1, 1958. Prior to that, it was the Water Research Division of the National Chemical Research Laboratory which was established in 1948. At the present time, they have a total staff close to 200 engineers, scientists and laboratory personnel.

The Institute has regional laboratories in Windhoek, Durban, Bellville and Bloemfontein to deal with problems peculiar to the specific regions.

The research activities of the Institute, which are carried out by six divisions and the regional laboratories, range from basic research to applied research on contract basis for industries, local authorities, provincial administrations and government departments.

The operation of the Institute is as follows:

Director: G. G. Cillie, Pr. Eng., Ph.D. (Cape Town), F. Inst. W.P.C., Member of the S.A. Akademie vir Wetenskap en Kuns

Chief Co-ordinator (Technical): L.R.J. van Vuuren, D.Sc. (Ind. Chem.) (Potch.), Dip. Eng. Chem. (Bradford)

Chief Co-ordinator (Technical Administration): W.H.J. Hattingh, M.Sc. (S.A.), Ph.D. (British Colombia)

The Institute is subdivided into five divisions, viz:

Freshwater Biology Division
Water Quality Division
Biotechnology Division
Physico-Chemical Technology Division
Technological Application Division

The responsibility and brief description of work done in each of the divisions is as follows:

Freshwater Biology Division

The utilization of freshwater systems by man often leads to influences on the biota of these systems. Thae rational management of freshwater systems has as, one of its aims, the minimizing of these influences to acceptable levels. The provision of knowledge for rational management is the primary task of the Division of Freshwater Biology.

Water Quality Division

The primary task of this division is the provision of chemical and biological analytical services to other divisions of the NIWR and for contract projects with outside bodies. Research activities include the updating and improvement of analytical services and studies on the chemical and biological pollution of water. Water quality criteria are reviewed and possible improvements are investigated. The staff consists of six research officers and 16 technical members.

Biotechnology Division

The research undertaken by the Biotechnology Division includes all biological processes for the purification of sewage effluents. The various projects form an integral part of the overall objectives of the research program, viz. the improvement of existing biological treatment methods and the development of new processes. Particular attention is being given to the development of techniques for the removal of plant nutrients such as nitrogen and phosphorous compounds from biological sewage treatment systems, without the addition of chemicals. This will provide three district advantages, viz. a substantial saving in expenditure on chemicals, which will become increasingly important if the cost of chemicals continues to rise; the reduction of eutrophication in natural waters into which the purified sewage effluents are discharged; an effluent more suitable for subsequent reclamation and reuse.

Physico-Chemical Technology Division

This division is mainly concerned with the reclamation of sewage effluent for reuse. The pricipal activities are the operation, evaluation and optimization of the Stander water reclamation plant at Daspoort, Pretoria. Laboratory and pilot-scale work is undertaken for the refining of unit processes and the development of new design criteria.

Technological Application Division

The Division of Technological Application makes available knowledge and information acquired through research and practical experience by the NIWR to all who may require it or who are in a position to apply it advantageously.

* * *

Published Papers

General Comments of Staff Relative to Wastewater Reuse in South Africa

As I mentioned, I spent a full day with the personnel of the National Institute for Water Research, but as you can be well aware, this was certainly an inadequate time in order to obtain a complete description and interpretation of their work. There were several comments that were made that I will relate to you at this time, which I feel more or less conveys how they look at wastewater reuse, both from a domestic as well as an industrial viewpoint.

1. They do not appear to be as concerned about viruses as we are in the United States. They indicate that they have never discovered virus in the effluent from one of their plants after going through "breakpoint" chlorination.

2. On the other hand, Mrs. Ethel Nupen has indicated that there has been viruses discovered in the treated effluent from their water treatment plant.

3. They feel that there is more of a problem relative to viruses dealing with runoff water than through water from either Windhoeck or the Stander plant.

4. They set the takeoff for their wastewater at a point above the discharge point of industry. -- They feel that they do not have sufficient information available at this time in order to attempt to handle combined domestic and industrial wastewaters.

5. During the serious time in Windhoeck, the maximum amount of reclaimed water that went into the system was 15%, in other words 85% was regular purified water.

6. They do not anticipate at any time would they go beyond 25% of the total supply as wastewater origin.

7. They go into what we would consider terminal reservoirs for mixing and do not now use or contemplate going to lake storage with one or two years retention time.

8. Even though they have spent a considerable time for the past twenty years in research that when the water is being used to mix clear water as a source for domestic supply, that they enter into what they call a "vigilant" laboratory and testing program. This is a very intensive testing program that they maintain.

9. Plant was shutdown after the first year of operation when a heavy rainfall alleviated the water shortage. -- The reason for the shutdown was a problem relative to algae production.

10. The feeling is that producing a sufficiently safe for domestic consumption is extremely expensive, but in the situation in Africa, they really have no choice.

11. The comment from Mrs. Ethel Nupen indicated that we in the United States were quite fortunate in that we had time to do research and investigation, but in the case of Africa, they shortage was on them and it was either a matter of taking a chance with a questionable wastewater reclamation program or not having any water.

12. African scientists have been working on research for about the last 20 years and more intensively in the last 10 years. -- This more or less ties in with the comments that we find in the States that about 10 years will be required in order to develop sufficient information where we can feel safe to use reclaimed wastewater for domestic supply.

13. They have done a great deal of work in industry to utilize reclaimed wastewater and have analyzed the requirements of the different industries and have conditioned the water for the particular use. An incentive program from the federal government has been instituted to encourage industry to use wastewater.

During my visit, I made arrangements to obtain copies of all of the technical papers that have been written in connection with their research on wastewater reclamation. I have attached a copy of this listing to this paper and if any of you are interested in any particular subject matter, let me know and I will make copies available to you.

Published Papers

In preparing this presentation I reviewed the papers furnished me in order that I could get some feeling for the work and research they have been doing and what their thoughts and attitudes were relative to wastewater reclamation in South Africa. So as to give you an idea as to their thinking and philosophy, I have excerpted the following comments and statements from the published papers.

1. Future Population Growth and Water Demand

Statistics broadly indicate that the country is heading for a substantial water shortage on a basis of current usage technology. Seen regionally, the problem becomes more accentuated, and in certain industrialized areas of the country socio-economic progress is already prejudiced by water shortages. Furthermore, the available fresh water in the hydrologic cycle is a fixed quantity. Consequently, our most constructive course of action calls for a critical appraisal of our present philosophies and technologies of water resources development and utilization. The challenges posed by this situation have forced the acceptance of the inevitable fact that water supply, beneficial use and reuse of water, waste water management and reclamation, and the control of pollution are inseparable components in a broad water conservation plan for every metropolitan area as well as for the country as a whole. This concept has stimulated scientists and engineers in the Republc to some remarkable achievements in water resources optimization which show that the country's future development will not so much be curtailed by actual quantities of fresh water available, but rather by our water resources management.

Excerpts

2. Water reclamation and reuse may yet prove to be the most practical solution to water shortages. The practice is likely to be forced on controlling authority in certain areas with increasing urgency. Reclamation should present no insupportable technical problems since the required expertise and equipment are readily available. It is, however, recognized that continued research will lead to improved economics and greater reliability. High-level radiation might well come into its own in the latter regard.

* * *

High-level radiation may well advance unrestricted reuse of effluents. Improved radiation technology can insure complete sterilization and breakdown of organic radicals which may be potentially carcinogenic. The present high cost of radiation and unfavorable economics may yet be overcome by continuous improvement in nuclear technology.

* * *

3. Reclamation is a practical solution to water scarcity in most conditions but adequate precautions must be taken in the design and operation of systems to protect the health of the individual and that of the community. Similar precautions are indeed necessary when polluted surface waters are processed for potable use, but these multiple safety barriers can seldom be expected with existing water treatment plants. Reclaimed water may thus prove to be a safer and more reliable water supply than those of doubtful origin.

* * *

4. Ethel Nupen questions the safety of existing water treatment plants in view of the fact that some of the raw water is as polluted as wastewaters and a nominal treatment plant is not designed to take care of the problems.

5. On reaching monitoring, no viruses isolated from final effluent of the Windhoeck Wastewater Reclamation Plant. Virus was isolated from the mixed purified Goreangab Dam and the Windhoeck reclaimed water. Intensive testing of all other sources of water supply to the Windhoeck area resulted in the isolation of virus from raw, natural water supplies and also from conventionally purified Goreangab Dam water.

6. The importance of properly controlled breakpoint chlorination with consideration of pH and turbidity is of cardinal importance, not only in disinfection of reclaimed water, but in all treated waters destined for drinking purposes.

7. For the purpose of supplying safe drinking water to a community, it is axiomatic to accept that all raw water supplies even underground water, not only in South Africa, but in virtually every country in the world can be contaminated with virus. The days of protected catchments and impoundments are over and the treatment in the conventional plant of what is virtually wastewater for drinking purposes is already a world-wide practice. The one major difference between this practice and direct reclamation of wastewater is that in the later system, the process units are designed in accordance with invironmental factors and the variables are under proper chemical and engineering control. This control is not always possible in the former case, where complete reliance is placed on the self-purification capacity of natural streams to deal with a highly variable source of polluted water and the conventional water purification works treating such waters have not been adapted to meet the requirement of the changing qualities of the raw water. There is therefore overwhelming evidence that reclamation can

produce a better quality water than a conventional water purification works when dealing with a polluted water supply. Vigilence is continuous and the proposed future operation of the Windhoeck plant will not only insure the production of a safe, potable water supply to Windhoeck, but will provide means to improve on the existing technological development and the acquisition of background information on the safety of all drinking water supplies.

8. South Africa is already moving along a critical path with respect to its available water resources. Within the next generation, water demand will exceed fresh-water supplies and future socio-economic development will depend on our ability to use and reuse available water resources efficiently. The optimization of waste water rehabilitation and the management and reuse of water requires, at national level, as much, if not in fact greater, far-sighted research, planning and financial input than the development of fresh-water supplies. A practical demonstration of this is afforded by Windhoek, the capital of South West Africa, which became at the end of 1968 the first city in the world to practise large-scale and continuous reclamation of waste water as an integral part of domestic water supply. Research is therefore being pursued at an undiminished rate to improve the economics and efficiency of waste water reclamation plants. The 4.54×10^3 m^3/d (1 mil gal/d) demonstration plant, currently operating at the Pretoria sewage works, will provide engineers and authorities with the necessary data and criteria for the planning, construction and operation of reclamation plants throughout the country.

9. Central and local government and regional water supply authorities now have at their disposal readily available data and expertise on which they can forge industrial water supply and waste water management policies which will encourage industry to contribute its share in the optimization of the country's water resources. The achievement of this objective, coupled with the fact that industry consumes only 15 % of the total water intake of a local authority serving an industrialized area, will ensure unhampered industrial development without prejudice to the water economy of the area concerned; the real problem is the increasing water requirements of the residential areas to accommodate a rising population. Consequently, the reclamation of sewage effluents as a source

of water supply must constitute an integral part of industrial development. Only then will it be possible to maintain a stable equilibrium between water supply and demand.

10. The writing is on the wall for both water-short and water-plentiful areas in South Africa. In the future it will be more advantageous to subsidize local authorities to reclaim their effluents than to develop new water schemes involving the piping of water over long distances.

11. A method for producing raw water of an acceptable quality for a water purification plant has been developed by means of biochemical denitrification and by harnessing the nutrient-stripping ability of algae.

12. High consumptive use of water in Windhoek prevents a high buildup of minerals through natural bleed-off.

13. Extensive bacteriological and virological testing have proved that a hygenically acceptable drinking water could be produced from sewage effluent on a practicable and economic scale.

15. The Windhoeck Water Reclamation Plant

This is the first permanent plant in the world to reclaim sewage effluent for domestic use. It resulted from joint research by the National Institute for Water Research and the Windhoeck Municipality. The plant was opened on January 21, 1969 by the Prime Minister.

The following is an excerpt from a paper presented at the 5th Internation Water Pollution Research Conference, July-August, 1970, "The Full-Scale Reclamation of Purified Sewage Effluent for the Augmentation of the Domestic Supplies of the City of Windhoeck", by L. R. J. van Vuuren, M. R. Henzen and G. J. Stander.

Introduction

The original planning of, and motivation for the Windhoek Reclamation Scheme and the preliminary investigations, including extensive laboratory tests and pilot-scale runs, were reported on in earlier publications. The design of the full-scale plant was based on criteria and experimental data which were available up to the end of 1965.

Early in September 1968, a critical situation in water supply and demand developed which necessitated the expeditious commissioning of the full-scale plant and the integration of this source of supply into the domestic water supply system of Windhoek.

The plant was officially commissioned on 21st January 1969, and up to June 1969, has produced one million cubic meters of reclaimed water. The public's favorable acceptance of the reclaimed water is ascribed to the progressive disclosure of information via the press and visits to the pilot and full-scale plants.

Quality of Reclaimable Sewage Effluent, and Water from Existing Sources

The reclaimable sewage effluent is derived from a conventional sewage treatment plant comprising of primary sedimentation, biofiltration, secondary sedimentation followed by further biological purification in nine maturation ponds in series with a total hydraulic retention of 14 days.

The existing water supply sources comprise of an impoundment reservoir (raw dam water) and 36 boreholes. The raw dam water is treated in a conventional plant whereas the borehole water is pumped direct into the main distribution reservoirs where it mixes with the purified dam water.

Efficient removal of ammonia is achieved in the ponds during the summer months while concentrations in excess of 10 ppm were recorded during the subsequent winter months. During this period, the chlorine demand is high. Facilities for stripping the ammonia by using lime dosing and stripping columns will overcome this limitation.

16. Stander Water Reclamation Plant

It is estimated that South Africa will have a serious water shortage before the end of this century. Water reclamation is one of the methods that can be applied to meet this shortage. It can play a key role in the conservation and optimum utilization of the water available to cities, for in large cities as much as 70 percent of the water used becomes sewage effluent. This constitutes an important source of water which so far has only been exploited to a limited extent.

The Stander Water Reclamation Plant, opened on November 11, 1970 by the Minister of Water Affairs, Mr. S. P. Botha, has a capacity of one million gallons per day. This plant which is to be used for futher research on water reclamation will serve as prototype for the planning of large-scale reclamation schemes in the Republic. It will also give the public the opportunity of becoming acquainted with the idea of water reclamation from sewage and realizing the degree of purity of the reclaimed water.

The feed water of the plant can range from raw sewage to the effluent from a conventional sewage purification plant and must pass through the stages of purification described in the following pages. The reclaimed water complies in every way with the standards for drinking water specified by the World Health Organization.

The processes incorporated into the Stander plant are as follows:

Foam Fractionation
Chemical Clarification
Ammonia Stripping
Stabilization
Sand Filtration
Breakpoint Chlorination
Carbon Adsorption

The design of the Stander Water Reclamation Plant was based on the research work that was done at Windhoeck.

Windhoeck Operation

The purpose of my visiting the NIWR at Pretoria was to check and evaluate some of the comments that I had heard relative to the degree of wastewater reuse in South Africa.

After getting back to the States and discussing my findings I received questions from various associates relative to certain phases of the Windhoeck operation that frankly I was not too sure of. I therefore wrote a letter to Dr. G. G. Cilliem who in turn referred it to Mr. Clayton, City Engineer of Windhoeck. I believe that the questions and answers pretty well sum up and clarify, at least from my standpoint, just what is happening and what has happened at the Windhoeck plant. The questions and answers that I have are as follows:

Questions from WRS letter of 10 February, 1976

Answers from S. J. Clayton, City Engineer's letter of 1 March 1976

1. During the emergency situation in Windhoek, what percentage of the total water supply was derived from wastewater reclamation?

   During the emergency situation in Windhoek, 1968-1969, approximately 15% of the total water supply was derived from wastewater reclamation.

2. Under your normal operation at Windhoek, what percentage of the domestic water supply is reclaimed wastewater? In one of your research papers, I believe it is indicated that approximately 15% of the total supply was derived from wastewater since the Windhoek Plant was in operation. Is this substantially correct?

   Windhoek's original reclamation plant was commissioned in 1968, however towards 1972 the growth of algae in our maturation ponds ceased and because the reclamation plant had no facilities for the removal of nitrogen, it was shut down.

   At present, the commissioning of a new, larger plant is in progress and this is capable of removing ammonia nitrogen. The capacity of this plant is 250m^3 per hour.

   When commissioning is complete, Windhoek will be supplied with water from four sources:

   (a) local catchment reservoir

   (b) reclaimed water from wastewater

   (c) boreholes

   (d) independent state supply scheme (from a dam some 75 km. distant)

The average daily water demand in Windhoek is 31000^3, of which $6000m^3$ could be the maximum supplied from reclaimed water. This is equivalent to 19%.

3. In discussions with your staff concerning the percentage of reclaimed wastewater that may be incorporated into a domestic water supply, it was my understanding that your studies have indicated that not more than 25% of the total domestic supply should be gleaned from reclaimed wastewater. Again, is this substantially correct and if so, is ther a particular reason why this figure has been designated. Has it something to do with a mineral buildup?

In Windhoek, the amount of reclaimed water mixed with run-off water was not restricted to the 25% which you mention, rather it was a question of capacity of reclaimed water able to be produced which governed this percentage. The plant produced water with a T.D.S. content far within the specified limits of Class A drinking water and providing this is the case I feel that no restriction is necessary.

4. As I interpret the flow diagrams, the reclaimed wastewater is mixed with the normal domestic water in a large storage tank before being introduced into the domestic system. Do you have any provision or have you in the past returned the reclaimed wastewater to your storage lakes for longtime holding? There is some discussion in the States of providing for one to two years storage in the water supply lakes.

"Water reclaimed from wastewater" has the effect of health authorities etc. wanting time to study the product and this is probably one of the fields of thought for the formation of the reclaimed water quality of reclaimed water storage lakes which you mention. Of course, the quality of reclaimed water to be passed into such lakes would not be as high as that reclaimed for immediate consumption and the subsequent sampling and testing procedure and operating efficiency control of the plant might tend to become less thorough with the knowledge that nature would lend a hand in the lakes. Also the storage lake water would have to be re-purified at the end of the one or two years retention period.
However, I might say that beautiful recreation facilities could be planned to augment such a storage scheme.
Windhoek has no provision for longtime holding of reclaimed water, nor has this been done in the past.

5. Am I correct in interpreting the written material indicating that 35% of the water supply returns to the sewerage system as compated to a normal anticipated return of 80%. This lower percentage is due to the fact that commercial and industrial wastewater is piped separately to a special plant for treatment. It is my understanding that in no event is the reclaimed wastewater introduced directly into the domestic system and that all reclaimed wastewater is mixed with surface water prior to entry into the domestic system. Is this a correct interpretation of your program?

You are correct in your interpretation that 35% of the water supply returns to the sewage works. This lower than normal figure is due to the fact that Windhoek, with its semi-arid climate, results in the people having to water their gardens 10 months out of 12. Also 10% of the water supplied is consumed by industry and the treatment of industrial wastewater is conveyed and treated at an entirely separate treatment plant.

Windhoek's water reclamation plant and catchment water treatment plant are located adjacent to one another but situated 15km. from the city and this is the reason why both waters are mixed at the treatment works and pumped from there to the domestic distribution reservoirs. However, providing the quality of reclaimed water meets with the specified standards, I feel that it could be introduced directly to the domestic system.

6. Are you considering the possibility of demineralization of reclaimed wastewater prior to mixing with surface runoff? Do you see any necessity for such a program?

Windhoek is not considering demineralization of reclaimed wastewater, because we do not have a problem with the amount of T.D.S. present, but obviously if this were the case then some form of demineralization plant would be necessary.

MORNING SESSION SUMMARY

By

George W. Adrian - Director, WATERCARE

Principal Sanitary Engineer
City of Los Angeles
Department of Water & Power

Presented at the Third Annual Conference, WATERCARE "Conservation Through Reclamation", June 10-11, 1976, Pepperdine University, Malibu Campus.

SUMMARY OF THE MORNING SESSION

by

George W. Adrian

Principal Sanitary Engineer

Los Angeles Department of Water and Power

Dr. Cleary mentioned that we are indeed humbled ("we" being the entire technical group of people involved in water use and water reclamation) by the task of defining parameters of water quality. And I have a task assigned to me this morning, by Will Stokes, which humbles me terrifically--and that's to summarize all these presentations this morning in a couple of minutes. I will try and do that and ask your indulgence if you picked up some things that I overlooked; by all means recall your own observations.

Beginning with Lloyd Fowler and his theme presentation-- "The Objective of Watercare Is A Desire to Extend The Community Water Supply Through Water Saving and Water Reuse Activities." From a technical standpoint we must learn what to do to reclaimed water - recognizing that at the present time certainly, and maybe for always, answers to certain questions will in the absolute sense be unknown. Another of our objectives in water care is to being in an administrative way both the water disposal and watey supply agencies, and to bring about an a-titude among both home and other water using agencies to accept reclaimed water.

Dr. Cleary presented to us a perspective on U.S. river waters and some of the problems in defining the water quality of those rivers. Going back to the early 1900's, subjective parameters or subjective judgment was used, for the most part, in determining the suitability of river waters for several different uses. About the same time objective parameters were recognized as being necessary and efforts were being made to establish those objective parameters. One of the earliest included free ammonia as a good indicator of water quality. Dissolved oxygen in 1908 was thought to be very important, and at that time was recognized as a controlling water quality parameter. With the development of Orsanco, it was recognized by the people involved that a great deal more hard information was necessary and desired, and could be obtained. So they started monitoring with 11 stations initially; as I recall, that is now expanded to 31 with an additional 21 installations serving as robot stations and taking hourly samples on an automatic basis and providing their analysis. Mr. Cleary emphasized that while we know certain things, there are many things that we do not know - and it is some of those things which we don't know which are most troublesome to us today. These include not knowing the effect of man-made pollutants relative to natural pollutants; the relative significance of natural chemicals as contrasted to synthetic chemicals; the significance for example of 500 million tons of sediment being transferred annually by U.S. rivers which is 250 times the total particulate input to those same rivers by man's activity. He emphasized that EPA through its legislative mandates is now investigating which compounds occur in our waters, in what concentration those compounds occur, and perhaps the big $64.00 question: What is the significance of those concentrations? In 1975 253 organics were analyzed for and determined to be in our water supplies. The big question agiain is what is the epidemiological significance of this? Currently, and extending on into the future, we will have the activities of the National Stream Accounting Investigation to provide basic data. The operation began initially with 345 stations, and now has 500 monitoring stations.

Frank Dryden presented to us the European practices, illustrating these on the continent with the Ruhr river which discharges into the Rhine river after ru=ning 170 kilometers or on the order of 75 to 80 miles. He pointed out that is a highly industrial area and that the communities and the industries discharge their wastes to the river generally after providing them with secondary treatment. The cities along the river, exemplified by the City of Essen, divert water from the river into naturally occurring sand areas. These sand areas provide a filtration of about 40 feet vertica-ly and 100 feet horizontally, and then the water is pumped directly from the groundwater aquifer and considered to be filtered water without chlorination, ozonation or disinfection, it is delivered direct to the domestic distribution system. They also provide a type of aeration to improve the water quality. In the Ruhr river droughts of 1911, reuse occurred to the extent of 100%; in 1929, reuse occurred to the extent of 300%, and in 1959 to the extent of 86%. Generally these reuses occurred during approximately one quarter of the year, and in some cases the statistical development of these figures is open to some degree of interpretation and judgment. In England, the Thames river on an average provides water which involves a reuse of approximately 14%, The Great Ouse River provides water in which about 40% of the flow represents used water. They are generally proposing a limit of relaimed water in the rivers of 75%, and are beginning animal studies with concentrates from these rivers that carry the reclaimed water and are also beginning epidemiological studies on community populations which use such rivers as the source for their domestic supply.

Bill Seeger presented to us a survey of the operation at Windhoek, South Africa, pointing out that as they began their operation they did not have time to develop information to answer a number of questions. That is, they knowingly entered into reclaimed water activity without full testing of a number of parameters that they would have liked to have the time to test for. However, they limit they're source for reclaimed water to only domestic sewage. They consider their reclaimed water is not directly reused because they put it through surface reservoir storage. A maximum of 15% of the water in a given reservoir is from a reclaimed water source. Because of the testing that they have done, they feel confident that their treatment provides a positive control of virus. They have an amazingly high degree of scientific coordination, investigation, and control of their reclaimed water activities even though they went into it on a sort of crash program. By their requirement remove pollutants and organics at the source, they provided incentive and encouragement to industrial plants to use their reclaimed water. Windhock personnle state that, "reclamation can provide any stipulated water quality, and therefore reclaimed water can be provided for any use, using the technology that is available." That's the way I understood it, but I'm not sure everybody would agree with that from the State of California

PUBLIC HEALTH CRITERIA FOR
RECLAIMED WATER REUSES (Title 22)

By

William Jopling, State Department of Health

Presented at the Third Annual Conference, Watercare,
"Conservation Through Reclamation", June 10-11, 1976,
Pepperdine University, Malibu Campus

PUBLIC HEALTH CRITERIA FOR

RECLAIMED WATER REUSES (Title 22)

Speaker: William Jopling, State Department of Health

I would like to discuss the reclamation criteria which are presently applied to reclaimed wastewater operations. I expect that most of the audience knows these quality and reliability requirements even better than I do; consequently, I would like to do more than just recycle the details of these requirements. I would like to briefly look back to where the reclamation criteria came from, how they were developed, and then give you the results of a recent study that the Health Department carried out on compliance with the present regulations.

The origin of health criteria for reclaimed water reaches back to 1907, and the first expressed controls for health purposes were pretty simple and straight forward. These initial controls were expressed in a letter sent out by the State Health Department asking local authorities to "watch irrigation practices and not allow the use of sewage in concentrated form or sewage polluted water to fertilize and irrigate vegetables which are eaten raw and strawberries."

In 1918 the State Board of Health developed its first formal regulations governing the use of sewage for crop irrigation. These regulations prohibited the "use of raw sewage, septic tank or Imhoff tank effluents or similar sewages or polluted waters for the irrigation of tomatoes, celery, lettuce, berries and other garden crops which can be eaten raw." Unfortunately, the next year we had our first water-borne disease outbreak associated with the irrigation of crops with wastewater in California.

Regulations were revised in 1933 to allow the irrigation of produce if the sewage effluent was well oxidized, reliably disinfected and filtered, and always met a bacteriological standard of less than 1 coliform per 100 ml. Even back then we were concerned about the reliability of the disinfection system and required that there be two or more chlorinators, weighing scales, reserve supplies of chlorine, and that the bacteriological analyses be performed twice daily.

In 1968, the State Health Department developed comprehensive quality regulations for uses of reclaimed water for irrigation of crops, public areas such as golf courses, parks and cemeteries, and for filling recreational and ornamental impoundments. This addressed quality; however, there were two other areas where some regulation was needed and these were (1) control over the reliability of the treatment system, and (2) control over the manner in which the reclaimed water was used.

We carried out surveys in 1969 and 1973 which confirmed our suspicions that people weren't using the reclaimed water properly. Spray irrigation in public areas was done when the public was present, drinking fountains and picnic tables were sprayed routinely, no notifications signs were used, and in some locations we found kids playing in the sprays. Certainly we don't have a sterile effluent under our quality requirements for irrigation of public areas, and there is a need for reasonable precautions so that the public is not directly exposed to the reclaimed wastewater. We developed "Use Area Guidelines" which describe good operational procedures and safety precautions for the use area. These have been well accepted and well received by the reclaimed water user, and we have found that we are getting much better operation and protection of the public than we did just a few years ago.

Our latest push has been to improve treatment reliability at reclamation facilities. It is important to note that the sewage of today is pretty much the same as it was in the past. With few exceptions we have the same disease organisms in it now that we had in the 1800's. What we have done with modern day sewage treatment is to provide a barrier to water-borne disease by removing pathogenic agents in the sewage before it is released to the environment. If the treatment process breaks down, the barrier is removed and we are right back where we were in the 1800's as far as disease transmission potential is concerned.

We conducted a series of studies in the 1960's and early 70's and consistently found that roughly 50% of sewage treatment plants were out of service some time during the year, and in most cases this had resulted in a serious discharge of inadequately treated wastewater. That record of reliability certainly was not acceptable at water reclamation plants where there is opportunity for public exposure to the undiluted reclaimed water.

At our request in 1969, a provision was added to the Porter-Cologne Water Quality Control Act that the State Health Department should establish not only quality standards but reliability standards for reclaimed water where such use involves the protection of the public health. In 1975 we adopted reliability standards for reclamation facilities which were producing reclaimed water for crop and landscape irrigation and recreational and landscape impoundments. Now we have coverage of both the quality of reclaimed water and the reliability features.

WATER QUALITY

The quality requirements for reclaimed water are presented in Table 1, as indicated, for irrigation of a non-food crop such as cotton or a fodder crop for cattle - all that is required is primary effluent. This also applies to orchards or vineyards which are surface irrigated.

TABLE 1

WASTEWATER RECLAMATION CRITERIA
QUALITY REQUIREMENTS

PRIMARY EFFLUENT

- Orchards & Vineyards
- Fodder, Fiber, & Seed Crops

OXIDIZED, DISINFECTED WASTEWATER

- (<2.2 coli/100 ml)
  - Surface Irrigation of Food Crops
  - Restricted Recreational Impoundment
- (<23 coli/100 ml)
  - Pasture for Milking Animals
  - Landscape Irrigation
  - Landscape Impoundment

OXIDIZED, COAGULATED, CLARIFIED, FILTERED, DISINFECTED WASTEWATER

- (<2.2 coli/100 ml)
  (max. = 23 coli/100 ml)
  - Spray Irrigation of Food Crops
  - Nonrestricted Recreational Impoundment

We require a disinfected secondary effluent meeting a median coliform bacteria number of 23/100ml for pastures for milking animals, for landscape irrigation (golf courses, cemeteries, etc.), or for landscape impoundments (water hazards at golf courses, etc.). Thus, the quality requirements become more restrictive as there is increased public exposure to the reclaimed water. Essentially, a requirement of no coliform bacteria (a median of less than 2.2/100ml) is applied for surface irrigation of food crops, or where the reclaimed water fills a recreational impoundment used for boating or fishing. We add a treatment chain which constitutes the best method presently available for virus removal for uses where there will be direct public exposure to the reclaimed water and some ingestion. Specifically, the reclamation criteria require an oxidized, coagulated, clarified, filtered, disinfected wastewater where the reclaimed wastewater is used to spray-irrigate lettuce, celery, or other food crops that are eaten raw, or where the reclaimed wastewater is used to fill a recreational impoundment used for swimming.

RELIABILITY FEATURES

Some basic features are required at essentially all reclamation facilities. These include flexibility of design, emergency power supply, and alarm systems. In addition, one of several alternative reliability features is required to assure that untreated wastewater will not be delivered to the use area. For example, the facility may provide some kind of short-term holding pond provided that spare parts are available so that the equipment can be repaired and returned to operation. As an alternative to this long-term retention or some alternative point of disposal may be provided. Multiple units can be provided so that one could be taken out of operation for repair. The reliability criteria are summarized in Table 2.

DISINFECTION

I'll describe reliability requirements for the disinfection system in a little more detail because what is of principal concern to the Health Department is the removal of pathogenic agents.

For uses which require a disinfected reclaimed water, the reclamation criteria include mandatory requirements for standby chlorine cylinders, a manifold system so that chlorine can be fed from more than one cylinder, cylinder scales, an alarm system, and an automatic changeover device. These are all essential features to enable a continuous application of disinfectant to the wastewater without interruption. Again, the criteria call for any of a series of options so that disinfection can continue or the wastewater can be stored if there is an equipment breakdown. A standby chlorinator is one option which can be provided to meet an equipment breakdown. Again, either short-term retention with spare parts, long-term retention - an alternative disposal point or any other reasonable option will prevent the discharge of undisinfected wastewater to the use area will be acceptable.

TABLE 2

RELIABILITY CRITERIA FOR RECLAMATION FACILITIES

I. Operation

- Engineering report on reliability
- Qualified personnel
- Maintenance program
- Operational records
- No bypassing

II. Basic Reliability Features

- Design flexibility
- Emergency power supply
- Alarms

III. Alternative Reliability Features

- Short-term retention and repair capability
- Long-term retention or disposal
- Multiple units
- Standby units

SURVEY FINDINGS

I want to cover briefly the results of a survey of reclamation facilities which the Department of Health conducted last summer. We visited 194 reclamation plants in California. The following are the uses that are made of reclaimed water.

TABLE 3

Type of Reuse	Number
Fodder, Fiber, Seed Crop Irrigation	139
Landscape Irrigation	44
Orchard and Vineyard Irrigation	16
Processed Food Crop Irrigation	14
Groundwater Recharge	8
Industrial Uses	8
Food Crop Irrigation (not processed)	6
Restricted Recreational Impoundments	4
Landscape Impoundments	4
Pasture for Milking Animals	3
Nonrestricted Recreational Impoundments	1

Forty-four of the treatment plants surveyed produced reclaimed wastewater for more than one use, thereby accounting for a total number of uses greater than the number of plants that produced the water.

We found only two places (these were places where food crops such as cucumbers and squash were irrigated) where the degree of treatment was not adequate for the type of use. On the other end of the scale, we found that where the reclamation criteria called for only primary treatment, 105 out of 139 facilities provided a higher degree of treatment than was required.

Daily coliform analysis is required in the reclamation criteria for 55 installations. Only 35% of the reclamation facilities fully complied with this requirement, but only 5% of the plants were not taking coliform samples at all. Consequently, at least an effort is being made to obtain bacteriological information at most facilities. It may be appropriate to reconsider the daily sampling requirement and allow a program which demonstrates the relationship of a bacterial number to chlorine residual and allows the use of the chlorine residual with periodic bacteriological tests to reconfirm the relationship. Apparently the daily coliform analysis is a major problem for some of the reclamation operation.

The following table presents information collected in 1970 on the reliability features for disinfection systems at plants where a disinfected wastewater is required.

TABLE 4

DISINFECTION RELIABILITY

	% of Plants Having Feature	
	1970	1975
Standby Chlorine Cylinders	95	90
Manifold system	53	71
Cylinder scales	80	61
Automatic switchover	3	33
Alarm	31	33

The reliability features which are presently provided at all reclamation facilities for treatment units other than the disinfection system are shown in Table 5.

TABLE 5

RELIABILITY PROVISIONS AT ALL RECLAMATION SYSTEMS

Basic Features	% Having
Alarms	44
Standby power supply	42
Alternative Features	
Long-term storage	45
Short-term storage	32
Multiple units	56

We are making a little progress, but I think you can see that we have a long way to go.

I hope that this has given you a brief picture of the present regulations and where we are now with regard to meeting them. Detailed information on California reclamation facilities is available in a 1976 Department of Health report, "Reliability of Wastewater Reclamation Facilities."

PUBLIC HEALTH CRITERIA AND RATIONALE FOR GROUNDWATER RECHARGE

By

William Jopling - State Department of Health

Presented at the Third Annual Conference, Watercare, "Conservation Through Reclamation", June 10-11, 1976, Pepperdine University, Malibu Campus.

PUBLIC HEALTH CRITERIA AND RATIONALE

FOR GROUNDWATER RECHARGE

Speaker: William Jopling, State Department of Health

The Department of Health has drafted proposed reclamation criteria for reclaimed water which is to be used for groundwater recharge. I would like to briefly describe how we got to where we are with regard to these groundwater recharge criteria before I go into describing them in a little bit of detail. The background is pretty short in terms of years, but I am sure that you will find it interesting.

In 1969, the Porter-Cologne Water Quality Control Act was added to the California Water Code. It directed the State Health Department to establish quality and reliability standards for reclaimed water which was used for various purposes. For the most part, this was a continuation of the authority that the Department of Health already had in previous legislation; but, in that year, the definition of reclaimed water was modified to include not only reclaimed water which was put to a "direct beneficial use" but also a "controlled use." This was something new. The change was recommended by a study panel to the State Water Resources Control Board in order that groundwater recharge would be included under the law in regulations covering wastewater reclamation. Up to that point, authority to set standards or criteria for reclaimed water covered only those situations where there was no intervening discharge into the waters of the State. With groundwater recharge, obviously you have a discharge into the groundwaters before the reclaimed water is used. So this term "controlled use" was added by the study panel to include that particular type of operation. Incidentally, the State Health Department was not involved in recommending that particular wording change.

Let me review certain actions of recent years which are pertinent to the development of criteria for groundwater recharge. From 1970 to 1973, policy statements on direct domestic reuse, pipe-to-pipe reuse, were issued by a number of responsible groups: American Water Works Association, Conference of State Sanitary Engineers, American Public Health Association, Water Pollution Control Federation, and others. Most of these statements (1) acknowledged the need to exploit the full potential of reclaimed water as a resource, (2) noted deficiencies in scientific knowledge regarding health effects, and (3) urged research on contaminants such as stable organic substances and their possible health effects before embarking on direct domestic reuse. Prior to this, the State Health Department had raised our concerns on the subject.

In 1973, the University of Illinois held a conference which was the first of its kind to convene a national group and focus attention on the lack of information on health effects of organics in drinking water regardless of the source of the organic chemicals. They concluded that there was a substantial lack of information and a need for inquiry. Last year, the World Health Organization and EPA sponsored conferences directed at the identification of specific research needs for direct domestic reuse. Trace organic compounds were an area for which substantial research needs were identified.

From 1972 to 1974, there was an increasing interest for the State Health Department to develop reclamation standards for groundwater recharge. For example, a study was conducted to determine the uses which could be made of the wastewaters entering San Francisco Bay. Options under study include the discharge into the Delta-Mendota Canal for agricultural irrigation in the San Joaquin Valley or recharge groundwaters in Santa Clara County. The issue of possible health effects resulting from the groundwater recharge option was raised in that study. Basin plans were being developed in that period and one of the guiding principles of the basin planning effort was to encourage the reclamation and reuse of wastewaters. Groundwater recharge involves a major volume use of reclaimed water at a single site which may be close to the point at which large volumes of wastewater are available. It avoids the problems involved in low volume, seasonal, scattered uses of reclaimed water such as golf-course irrigation. As a result, over 30 possible groundwater recharge operations were identified in the plans. Although the total amount of reclaimed water proposed for recharge in the basin plans is not very significant in terms of the total water demands of the state, implementation of the projects would result in substantial amounts of reclaimed water in certain groundwater basins. Principally, in response to the basin plans, the State Health Department developed a position statement in 1973 calling essentially for a moratorium on projects that would result in significant amounts of reclaimed water in a groundwater basin.

In 1975, the State Water Resources Control Board, Department of Water Resources, and State Health Department established a consulting panel on the health aspects of wastewater reclamation for groundwater recharge. The purpose of the panel was to identify a research program to answer the health questions on groundwater recharge. They have identified a significant body of research needs on this subject. Certainly, the findings of this panel will guide us in what our regulations ought to be and how they should be applied.

In 1975, the Director of Water Resources and the Vice Chairman of the State Water Resources Control Board met with the Director of Health and urged that draft criteria for groundwater recharge be developed and public meetings on these be held. This is what we have proceeded to do.

There have been other activities which relate to this matter and, briefly, here is what they are. In 1974, EPA conducted a study of organic chemicals in drinking water supplies in 80 cities throughout the United States. They uncovered a variety of specific organic substances in the waters. The Environmental Defense Fund in a controversial finding related a higher cancer death incidence to the consumption of New Orleans water supply containing organic contaminants. In December 1975, EPA proposed interim primary drinking water standards which included provisions for studying water supplies of 112 cities for 20 organic chemical compounds and six indicator substances. This study will provide information on levels of specific organic substances in water supplies which are influenced to different degrees by sources of pollution. This information is to be gathered during 1976, and the work should be completed by the end of the year. Along with this quality information, EPA will be conducting epidemiology studies of selected communities and will be making determinations, insofar as possible, of maximum allowable limits of various contaminants. Certainly, also in the area worth noting, the EPA and State Water Resources Control Board are sponsoring research at Palo Alto and Orange County Water District to determine the nature of organic substances in reclaimed water use for recharge.

So, finally, after half-a-dozen years, we have definitive efforts underway to get information on which to base standards. But right now we are faced with the prospect of attempting to set criteria which will provide assured health protection when no definitive conclusions have been reached in this matter.

RECHARGE POTENTIAL

Table 1 presents the present water demands in California and the present and future recharge projects. The figures may not be exact, but they do provide a general indication of the relative volumes of water. About a quarter-million acre-feet of reclaimed water could be recharged if all projects were implemented. Most of them are located in the central and southern portion of the state.

In spite of the small percentage of reclaimed water that could be recharged in comparison to the total water demand, the projects are significant because the implementation of the proposed projects would result in high percentages of reclaimed water in certain water basins or certain portions of water basins in California. The specific proposed projects are presented in Table 2.

PROPOSED CRITERIA FOR GROUNDWATER RECHARGE

A draft of proposed criteria for groundwater recharge has been distributed recently to over 800 waste dischargers, communities, consulting engineers, regulatory agencies, and other interested parties. Informal public meetings are scheduled for late in June in order to obtain comments and recommendations before we proceed into any formal processing. These meetings will not commit anyone to anything. The proposed regulations are not cast in concrete; they are our present thinking based on what information is available in order to provide assured health protection. I would like to remark on the reasons for each portion of the criteria.

Treatment Requirements

The criteria require secondary treatment plus carbon filtration and reverse osmosis. Why carbon treatment and reverse osmosis? These two processes provide the most effective treatment chain for removal of soluble organic material in reclaimed water. As far as we know, there is nothing that can do an equivalent or better job. By itself, carbon adsorption will reduce the COD (Chemical Oxygen Demand) of the secondary effluent down to about 10 to 20 mg/l. Reverse osmosis will result in a COD of 1-2 mg/l. It is certain that this treatment requirement will be the principal point of discussion and contention of the public meetings. We hope to obtain comments and recommendations on possible options to the requirement or possible alternatives. We expect to receive a great deal of information on this at the public meetings.

Quality Requirements

Reclaimed water will be required to meet the mandatory physical and chemical requirements of the California Standards for Domestic Water Supply. These consist of limits on certain heavy metals, toxicants, and pesticides. A nitrogen level of 10 mg/l is also applied. A limit is also specified for COD - a median of 2 mg/l, and a maximum of 5 mg/l. This is intended to be used as an indicator that the treatment processes are performing effectively. There is no known or intended health significance to that level of COD; it is just as an indication of the process efficiency. Finally, the effluent is to be monitored for 20 specific organic compounds that EPA has included in its study of water supplies throughout the United States. No limits have been established on these. The purpose of monitoring for these organics is to provide an indication of the level of such substances in reclaimed water in comparison to the existing domestic water supplies in the country.

Time and Distance Requirement

A minimal vertical distance of 20 feet of travel to groundwater is specified. Also, the reclaimed water must remain underground for a year prior to withdrawal through a community domestic water supply well. These two provisions will assure that there is a maximum use made of the treatment capability of the soil mantle and no biological agents will survive. Further, there would be ample opportunity to detect and correct any problems that may exist from the recharge before the water is extracted.

Source Control

The source control requirement is included in general terms to control or limit the discharge of possibly harmful industrial substances to the reclamation facility. Source control activity would probably involve a survey of industries in the collection system and the types and amount of wastes which are discharged. The intent is not to provide a wastewater that is free of industrial waste, but in the manner of Whittier Narrows, to minimize the industrial input to the reclamation facilities either by proper location of the facility, separation of wastes, or some other control.

Biomonitoring

What is intended is a simple on-line fish tank which would alert the operator to a possible spill of a contaminant which might have passed through the treatment system. No other monitoring that we have required will detect slugs of contaminants.

Health Monitoring

This is a concept that our medical advisors particularly recommended for inclusion. It would involve health indices monitoring. While it may not be possible to effectively identify health changes through some type of epidemiological surveillance activity, indices of health effects may be obtained by monitoring changes or accumulation of contaminants in human deposition sites, possibly an accumulation of selective substances in hair, nails, ear wax, or tissue. The program would be developed on an individual case basis with the appropriate health authorities.

Groundwater Monitoring

The recharge of contaminants could occur between the bimonthly or semiannual monitoring that is required. Since movement in the underground will be relatively slow, groundwater monitoring at infrequent intervals could detect any quality problems and allow for remedial action. This program would also assure that any adverse changes such as pickup of iron from the soil would be caught and detected.

Hydrogeologic Study

A hydrologic study is required in order to provide data on underground formations, general soil characteristics, locations of aquifers, and groundwater movement that would assist in the evaluation of the project.

Operational Practices

It is important to detail the method of operation. Provisions for intermittent application of the reclaimed water and maintenance of an aerobic zone of percolation are examples of important operational factors in the project.

This covers the proposed criteria for groundwater recharge which will be the subject of discussion at several informal meetings.

TABLE 1

GROUNDWATER RECHARGE WITH RECLAIMED WATER

Water Demands of California*	Acre-Feet Per Year
Domestic & Industrial	5,000,000
Agricultural	31,700,000
Wildlife	700,000
Total	37,400,000

Wastewater Available for Reclamation*	Acre-Feet Per Year
Available Wastewater	1,700,000

Present Groundwater Recharge**	Acre-Feet Per Year
1 Major Project	23,500
5 Minor Projects	1,100
Total	24,600

Future Groundwater Recharge***	Acre-Feet Per Year
7 Major Projects	183,300
29 Minor Projects	76,400
Total	259,700

* The California Water Plan, Outlook in 1974 - DWR Bulletin No. 160-74.

** Inventory of Wastewater Production and Wastewater Reclamation in California 1973 - DWR Bulletin No. 68-73.

*** Water Quality Control Plan Reports (Draft) SWRCB 1974.

TABLE 2

PROPOSED GROUNDWATER RECHARGE PROJECTS*

BASIN	PROJECT OR AREA	FLOW** (Acre-Feet/Yr)
3	Watsonville	8,960
	Paso Robles	1,200
	King City	700
	Pacific Grove Area	6,330
4A	Eastside	1,300
	Camarillo	2,150
4B	Sepulveda	24,640***
	San Jose Creek	47,040***
	Whittier Narrows	12,320***
	Las Virgenes	448***
5A	Sacramento Metropolitan Area	27,280
	Redding	6,210
5B	West Sacramento	3,810
	Mokelumne River Area	2,170
5C	Modesto (Ceres)	12,640
	Madera	4,010
	Oakdale	1,450
	El Nido (Gustine)	3,020
5D	Edison-Maricopa	220
	Kern River Delta	2,180
	Visalia-Hanford	8,470
	Tulare	3,960
	Delano-Earlimart	3,030
	Shafton-Wasco	2,230
	Porterville	2,130
	Fresno	34,220
6A	Suprise Valley	-
	Honey Lake	-
6B	Apple Valley-Desert Knolls	-
	Victor Valley	4,480
	Barstow	5,040
7A & B	Upper Coachella Valley	2,850
8	March AFB Perris Valley Sun City San Jacinto-Hemet	25,112
	TOTAL =	259,610

*The proposed projects are those identified in the Water Quality Control Plan Reports prepared for the California State Water Resources Control Board.

**The flow figures are the average daily flows for 1973 at the existing treatment facility in order to provide a rough idea of the amount of recharge. No recharge flows were generally given in the Reports.

***Year 2020 flows.

PUBLIC HEALTH CRITERIA AND RATIONALE

FOR GROUNDWATER RECHARGE

QUESTIONS AND ANSWERS

Question: Can you tell us what is the cost of the analysis of these 20 organic compounds?

Answer: I can't give you a definite cost. In our recommendations on requirements for the Chino Basin groundwater recharge operation we have asked that they run tests for PAH's (polycyclic nuclear hydrocarbons), which are approximately six different substances, and I think it is going to cost them $1,000 a month to run those tests. So, it is going to cost a lot more than that.

Question: The regulations seem to cover groundwater recharge by spreading rather than by injection. Will you comment on this?

Answer: Yes. Regulations for groundwater recharge by injection must go through a completely different administrative process to get approval. They have to go before the Director of the Department of Health to make a finding on that particular case. That is under another section of the Water Code and the Health and Safety Code.

Question: The requirements look better suited for injection than for recharge by spreading, in my opinion, but looking at the requirements you have set and the treatment train you have specified, it appears that you are not depending on the ground to provide anything in the way of treatment. Would you comment on that philosophical position.

Answer: As has been demonstrated at Whittier Narrows, there is a tremendous capability for the soil to provide treatment - particularly in the area of biological concerns (bacteria and viruses) and in the area of heavy metals. I think chromium perhaps is the one heavy metal that passes through the soil system, whereas most of the others are absorbed fairly well. With regard to organic substances that are not removed by treatment, I do not think we know very much about their removal by the soil. Certainly this is something a demonstration project should be directed at to get additional information.

Question: Is there any method by which you can monitor the absorption capacity of the soils or a method of increasing the capacity, such as changing the pH and that type of thing?

Answer: Some work has been done at the Sanitary Engineering Research Laboratory at Berkeley in determining when a breakthrough occurs just by loading a soil column. At Santee the soil was loaded for many years and no evidence of a breakthrough of bacteria or viruses was observed. Of course, there are some adverse effects with the soil mantle if the constituents in the water are such that the mineral content is increased. As far as determining the capacity of the soil, I don't think that has been truly identified.

Question: One of the proposed requirements is that there must be a minimum vertical distance of 20 feet of soil to the groundwater that is unsaturated. After you have been putting water on soil for a while, how do you maintain this unsaturation?

Answer: As I understand it, what you attempt to do is not to allow the groundwater recharge mound to rise up to the bottom of your spreading area by operating the system intermittently. That is, you apply water and then provide a resting period so the mound can go down, thus maintaining an aerobic zone.

Question: Do the proposed regulations require spreading on bare ground, or could it be spread on crops?

Answer: What we have attempted to do is not prevent, in any regard, the use of reclaimed water for agricultural purposes. We certainly don't want to say - "No, you can't use it for irrigation because this is groundwater recharge" - even though some incidental amount of water does reach the underground. No restraint would be placed on an operation if you meet these requirements and use the water for irrigation of crops. We haven't set a disinfection requirement. We haven't required chlorination or anything like that.

BLUE RIBBON PANEL AND STATE WATER RESOURCES CONTROL BOARD ACTION PROGRAM ON WASTEWATER RECLAMATION

By

Jan Stofkoper - Assistant Unit Chief,
Statewide Policy Development

Office of Planning
California State Water Resources
Control Board

Presented at the Third Annual Conference, WATERCARE, "Conservation Through Reclamation", June 10-11, 1976, Pepperdine University, Malibu Campus.

Blue Ribbon Panel and State Water Resources Control Board (SWRCB) Action Program on Wastewater Reclamation (WWR)

by Jan Stofkoper*

Thank you for the opportunity to talk about this important subject: "The Blue Ribbon Panel findings, the SWRCB's action program on WWR, and how these two areas relate to each other."

First, let me tell you a bit more about the Blue Ribbon Panel.

The members of the Blue Ribbon Consulting Panel, or more accurately, the Consulting Panel on the Health Aspects of Wastewater Reclamation for Groundwater Recharge, were brought together in 1974 through the joint action of the State Health Department, Department of Water Resources, and the SWRCB. The Panel consisted of nationally known experts in the fields of wastewater management, public health, and related areas.

The Panel's main charge was to, and I quote, "to recommend a program of research that will, first: provide information to assist the Department of Health to establish reclamation criteria for groundwater recharge, and second: assist the Department of Water Resources and the SWRCB to plan and implement programs to encourage use of reclaimed water consistent with those criteria."

This charge accurately reflected State government's dilemma in wanting to optimize WWR through recharge and, at the same time, being restricted by a number of possible public health risks that could result from such recharge.

* Office of Planning, State Water Resources Control Board, Sacramento, CA

Mainly, we were concerned about virus removal, bacteria, and stable organics; stable organics mainly because of its carcinogenic characteristics.

I believe that I don't have to go into any more detail on the health risks involved. The previous speaker, Mr. Jopling of the State Health Department, has just sufficiently covered these conceivable dangers of WWR.

The Blue Ribbon Panel met three times over the past year, for a total of 50 hours, and in February of this year, came out with their final report. I should mention the fact that the 3 state agencies, prior to the Panel's first meeting, prepared a comprehensive report: "A State-of-the-Art", which reviewed the present knowledge on this subject and which has been used extensively by the Panel.

Without reading the total Panel report to you, let me just highlight some of the research needs identified by the Panel. Let me say a few words about each of these seven categories:

1. Characterization of the contaminants in reclaimed wastewater and in recharge aquifers.

   The Panel recommends that we start immediately with the task of identifying chemical compounds in drinking water supply samples taken from existing wells where the aquifer was recharged with wastewater. This information must then be related to intensive analytical studies of the waters initially applied for recharge.

2. Study of water treatment processes for the removal of potentially harmful organics.

The Panel states that, although present technology can produce water containing total organic carbon of 1 to 2 mg/l, there may be a need to even further reduce these levels (if it could be concluded from future studies that such levels could pose a health risk). Processes that could be researched are:

a. Adsorption into activated carbon and specific soils;
b. Other methods such as biological oxidation, ion exchange, membrane processes, and chemical treatment.

3. Study of disinfection techniques and of viruses.

Chlorination has been a fairly standard disinfectant. However, recent questions concerning its strength as a viricide and possible carciogenic aspects of chlorinated compounds may require alternative means of disinfection, such as ozone.

Also, the Panel recommends that we study the best timing for disinfection. Should it be done before recharge of the aquifer or after withdrawal, or maybe even in both cases?

According to the Panel, the advantages of disinfection after withdrawal would be that the soil column could be effectively used as a biodegradation and waste removal system of organic compounds which would result in fewer chloroforms. However, the danger exists that pathogenic microorganisms would survive and would move through the soil system without being destroyed.

4. Studies of the behavior of pollutants in soils and sediments in the underground environment.

The Panel recommends that we study the sorption kinetics of harmful substances on unsaturated soils and sediments. Such a study will add greatly to our knowledge and understanding of the treatment capacity of soils and the resulting quality water.

What are harmful substances? The Panel mentions potentially harmful organics, including organics that result from chlorination of wastewaters. Also, the Panel recommends that in this context we study the interactions between organics and heavy metals and see to what extent they may influence the adsorption and desorption. Furthermore, the Panel recommends that we study the rate of biodegradation of organic compounds.

The Panel suggests that we study such phenonema not only in the laboratory but also in the field. According to the Panel: "field measurements of existing or new pilot studies of wastewater reclamation and groundwater recharge by surface spreading of reclaimed waters are absolutely essential. The contributions of such factors as distance, geologic stratification, and microorganisms on the natural underground treatment process cannot be satisfactorily incorporated into laboratory studies."

5. Assessment of toxicological risks

The Panel identifies four levels of research activity to assess toxicological risks:

a. The first level applies to the studies of how human individuals react differently to certain concentrations of pollutants, how to refine the mathematics of calculating the actual risks involved, and how to improve the extrapolation techniques from toxicologic findings in experimental animals to humans.
b. The second level applies to the area of chemical analytical methods and the need to know the quantity and quality of chemical compounds in treated wastewaters and present drinking water supplies. (The Panel senses that such water quality analyses have little value unless they are accompanied by epidemiologic studies of humans ingesting those waters. I will say more about this later.)

c. The third level of effort should begin without delay. We need to select out those compounds which are potentially toxic and immediately begin studies with experimental animals to determine their chronic effects. This, of course, is similar to the first study area mentioned, but I think it important encough to bring up again in a more comprehensive context.

d. The fourth level of research would be to continue development of procedures that promise to provide a relatively rapid method of screening for toxicologic hazards.

6. Epidemiological studies of exposed populations.

California has never conducted an epidemiological study in which we tried to determine the relationship between chronic diseases and the ingestion of wastewaters. However, we have conducted such a study for air quality in Southern California and the Panel suggests that we consider the elements of the study and how it was conducted.

According to the Panel, the plan of study should contain four essential elements. They are:

a. Selection of Communities. Every attempt should be made to limit the difference in selected communities to the factor of water supply only. The studies should be carried out in communities which have obtained their water from supplies which haven't changed much in quality for a number of years. This way we will be able to conduct retrospective studies and save valuable time.

b. Characterization of the Environment. In order to clearly identify the effects of water quality only, we also have to identify the possible health effects of other environmental factors such as air quality, climate, population density, noise, land use, etc., and the possible relationship between two or more of such factors.

c. Characterization of the Population. We should know the general makeup of the populations to be studied. Their race, sex, age. What are their smoking, drinking, and eating habits? These and other similar questions need to be answered.

d. Disease Surveillance. The objective of any epidemiological program is, of course, to find the relationship between certain environmental factors, in this instance, water quality, and specific diseases. Consequently, a disease surveillance program is very important and should be conducted. Information should be collected on certain selected disorders and their symptoms. What are the mortality and morbidity rates of disorders such as cardiovascular, nervous systems, liver, kidney? What are the statistics in cancer? What information do we have on mutagenic and tertogenic disorders?

7. Research and application of monitoring techniques and strategy.

Not much needs to be added to this category. It is obvious that, to effectively conduct any future research project, an adequate data base and further monitoring of ongoing WWR processes is needed.

Many of us involved in the field of water conservation, water resources development, and WWR differ in our opinions as to how we should approach this research in the near future. Is WWR safe? Is it dangerous? What are the health risks involved? Are there any health risks, or are we all just concerned for no reason? It is my feeling that for the next few years we just don't know, and as long as we are not able to clearly respond to such questions, either affirmative or negative, substantiated with convincing research data, it will be difficult to convince the general public, the taxpayer, that we should go full steam ahead in wastewater reclamation.

I'd like to conclude the Panel's recommendations with a direct quote from their report:

"Serious deficiences exist in our knowledge of the effects of particular components in water supplies in the health of individuals consuming the water. Yet, it is a recognized fact that a few groundwater recharge projects have operated for a number of years with no apparent harmful health consequences. But, health studies have not been conducted, and until they are, we cannot be sure whether there have been health consequences. Additionally, it should be recognized that such studies are rendered exceedingly difficult by the long latency period associated with some of the effects. In view of this situation, therefore, the consensus of the Panel is that needed research should go forward."

The Panel had another interesting comment with regard to project funding, project time involved, and lead agencies. The Panel recognized that needed research costs are large, probably in the order of tens of millions of dollars. The time to complete the research will take at least 10 years. The basic issues that need researching are of a national character. Based on these statements, the Panel suggests a national sponsorship and funding. For example, the EPA could serve as a coordinating agency. Research itself, of course, could be done by federal, state, and local agencies, universities, and private organizations.

The question that may be asked is what does the SWRCB intend to do with all this information. Certainly, we don't have the funds available, nor the manpower, to independently conduct such research projects. Research projects by the State Board are funded out of either the Clean Water Bond Funds or General Funds. Annual allocation for research is somewhere in the neighborhood of a half-million dollars. According to the Blue Ribbon Panel, total cost for all research will be in the tens of millions of dollars. The State Board just doesn't have that kind of money.

Maybe an answer could be to incorporate some of the Panel's recommendations in a longrange program for WWR--a program to be conducted by the SWRCB.

As you may know, last year the SWRCB started the development of an action program for reclamation and reuse of wastewaters. We felt that such a program is necessary to fully implement the legislature's intent to augment WWR in the State. The development of the action program should take about one year and should be available for public comment and State Board approval in December of this year.

The Board recognized that such a program could not be developed by the staff alone. Instead, the Board believed that a broad, diversified input from many agencies early in the development stage would make for a more comprehensive program and would add to its public acceptability. For this reason, the Board set up a Task Force, chaired by Mrs. Auer, Board Member. This Task Force consists of about 60 people representing a great many state, federal, and local agencies and special organizations, such as the Sierra Club, League of Women Voters, and, of course, Watercare.

The Task Force really develops the action program. The Task Force is divided into 5 or 6 subgroups, committees, that take responsibility for studying and analyzing specific elements of WWR. We have committees on water rights, grant funding, regulation and enforcement, environmental impact, education, and criteria, research, and development.

Each of the Committees consists of about 10 people. The Committees study specific issues and make recommendations to the entire Task Force as to certain actions to be taken. For instance, the Criteria, R&D Committee, in one of their recommendations, stated that at this time insufficient criteria are available to reuse wastewaters to their fullest potential and that more research, in a variety of areas, is needed to obtain the necessary data from which criteria can be developed. As Chairman of this Committee, I intend to recommend to the Task Force that other agencies, in addition to the State Health Department and the SWRCB, should be held responsible for setting and enforcing WWR criteria. As an example, no criteria are available that would apply to the protection of agricultural land from the possible impact of long-term irrigation with wastewaters. Demonstration projects are needed that would give the government agencies more information to set criteria and the farmer more confidence in reusing wastewaters on his lands.

With regard to the Blue Ribbon Panel, the Committee on Criteria, R&D will review the Panel's recommendations and recommend to the Task Force as a whole which of the recommendations ought to be included in the WWR action program.

In doing so, we have to consider the following points:

1. Money
2. Research being conducted outside California (now or in the near future)
3. Research already being conducted here in California

Even though the Board may not have a lot of money, we have about a half-million dollars a year, we can use these funds as seed or matching money. What this means is that we can start the first phase of a research program and obtain federal funding--for instance. from the EPA--for the remainder of the project. Normally, the State would pay 25 percent and EPA would pay 75 percent.

Another alternative would be to use monies from the Clean Water Bond fund. If an applicant for a treatment facility wants to conduct certain research that is compatible with other existing or proposed research programs, he can obtain funding as part of a step-one grant.

Of course, all of this money taken together is still insufficient to meet the Blue Ribbon Panel's estimate of "tens of millions of dollars". We have to realize though that not all research has to take place here in California. Other states in the USA, in fact other countries, are equally concerned about conserving water, reusing it, and maintaining adequate standards.

In Europe, for instance, longrange proposals have been made for more and more research regarding the health effects of direct ingestion of reclaimed water. Findings of such programs can easily be used for WWR methods such as groundwater recharge. The WHO, last year in Amsterdam, came out with a comprehensive report on research needs and called for international coordination. In Windhoek, South Africa, data is being collected on the recharge of aquifers with WWR, as one of the previous speakers discussed today. Also, of course, a number of projects are being conducted in the USA.

Incidently, we have to realize that neither the Criteria, R&D Committee nor the Task Force as a whole will come up with specific research programs in which we identify where, when, and how research should be conducted. The Task Force action program and recommendations should provide longrange, comprehensive direction. It should provide a framework in which from year-to-year the State Board can allocate funds for specific WWR research projects.

For this purpose, the SWRCB, together with the SHD and DWR, has set up a coordinating committee in which specific research projects and their location will be identified.

As an aside, it would make a lot of sense if we could somehow set up some kind of interstate and international coordination through which we will get more efficient exchange of information of existing data so that we can plan for additional needed research.

In order to do so, we need to answer some questions. For instance:

- What international organization would be best suited to undertake such a task? Would it be the WHO, FAO?
- Who should initiate it?
- What funding is available? Who should pay, and for what?

On the technical level, we could ask the question, do Europeans know enough about the American way of water treatment, and vice-versa, to adequately interpret and apply each other's data?

Within the USA, we have, of course, the federal government and a number of research organizations such as NAS, Rand, etc., which could coordinate and conduct research programs.

I realize that the idea of international coordinated research is still poorly defined and poorly formulated. However, I think that we can obtain a lot of knowledge, and save a lot of time and money, if we are willing to spend some time on international coördinated research. Considering the many issues that need to be resolved, isn't it about time that we get to work on this?

Before I conclude, I have one more comment to make. Sometimes I hear people say that we are spending a lot of money in research for direct or indirect reuse of wastewater while agriculture could effectively reuse almost all of the available wastewater. Granted, use for agriculture would probably be less risky, there are fewer unknowns, it is more acceptable to State Health. However, institutional arrangements have not been sorted out yet, particularly interbasin transfers.

Because of these and other unknowns, the doubts that the agricultural community have with regard to WWR, the time involved in setting up demonstration projects, the time involved in resolving institutional problems, all these taken together may effectively delay WWR for an undetermined period of time. Therefore, I don't think that we are spending our time and resources on the wrong priority. I believe that any effort spent on resolving the WWR issues with regard to groundwater recharge will get us closer to making the best use of our wastewaters, and, in all practicability, of our total water resources.

PANEL DISCUSSION: BENEFIT VS. RISK FROM RECLAIMED WATER - IN PERSPECTIVE

Moderator - Dr. Gerald H. Meral, California State Department of Water Resources

(This panel discussion was edited from tapes by Mal Toy, Los Angeles Department of Water & Power)

- Presentation - by Dr. John Goldsmith, California State Department of Health
- Presentation - by Dr. Ronald A. Howard, Department of Engineering Economic Systems, Stanford University
- Presentation - by Dr. Warren Winklestein, Dean, School of Public Health, University of California, Berkeley
- Panel and Audience Discussion

Presented at the Third Conference, WATERCARE, "Convervation Through Reclamation", June 10-11, 1976, Pepperdine University, Malibu Campus.

BENEFIT VERSUS RISK FROM RECLAIMED WATER IN PERSPECTIVE

Presentation by Dr. John Goldsmith,
California State Department of Health

My remarks will be mercifully brief because I know pitifully little. I certainly know almost nothing about the benefits, other than being a citizen and feeling that water reclamation is a direction in which we are capable of going, and that we should with care, caution and a certain amount of determination. As far as risks are concerned, whether I like it or not, I am in the business of evaluating health risks for the State Health Department when environmental exposures are the source of these risks.

Groundwater recharge is the hot topic. But I understand we are also suppose to discuss other risks of reclaimed water as far as human health is concerned. I think we have effective regulations.

I find myself with some trepidation regarding the adequacy with which these regulations and the requirements will be met, because when all is said and done, new technology is to be used which contains risks for which regulations are the protective mechanism, and since these regulations are not being systematically applied or uniformly enforced, the whole game becomes somewhat more academic or more bureaucratic (to be even more accurate) and less protective. I have to say that I believe that the systematic application of regulations for disinfection and application of reclaimed wastewater and sewage and recreational impoundments should be made more effective. But when there are such regulations and requirements in existence, then full-scale compliance is in the public interest.

With respect to groundwater recharge, I am willing to say what I think some of the risks are, but then I will have to admit that the nature of the epidemiologist art, craft, skill, or deception is such that he is expected to be adept at rolling up the carpet that he is standing on. What this really means is, that we are going to be faced with the necessity of measuring the frequency of occurrence of events in which we are trying to protect from occurring to people. That is a difficult problem, which I am sure you will recognize. It is not impossible, and it is not impractical, and it is not unnecessary, but I will do my best to tell you what a course of thinking in analysis may mean with respect to this problem.

What are the risks? The risks are that reclaimed sewage may contain materials which will have long-term disease effects. We are currently in a period of evaluating the carcinogenic hazard of chlorinated hydrocarbons. Many of these agents, you may have read about in the newspapers but the scientific data I haven't read about in the scientific journals as yet, have to do with chloroform and its carcinogenicity. The data is such that, when these materials are injected (usually at very high doses) in experimental rodents, tumors are produced. The question of how this is related to human cancer and the risks of human cancer is a difficult question. If I have to guess, and the epidemiologist often has to start by guessing, I would guess that the greatest cancer risk now detectable from wastewater reclamation probably would not be related to chlorinated hydrocarbons, but may very well be related to groundwater increases in nitrate, and therefore, water increases in nitrate. Under some circumstances, nitrate will form in the gastrointestinal tract a highly carcinogenic class of agents called nitrosamines. I believe a recent report from UCLA suggests that there was a epidemiologic association between groundwater nitrate levels and gastric cancer rates in Chile. That work is just starting, and much more needs to be done. Its experimental counterparts are also just starting, and their ability to measure nitrosamines is rather modest. Thereby does hang a risk, and the risk is one of the approximate measures of hazard. This is the point I want to stress, because it seems to me that we have been ignoring it. The approximate measures of hazard are what the nitrate levels are in the first place, and then what proportion of the nitrate may be reacting to form nitrosamines and the possible index which is available and which we have demonstrated of the level of methemoglobin in circulating blood.

The second set of risks is a set of risks related to viral infection. I won't belabor the point other than to say that, if treated wastewaters are used for groundwater recharge, one wants to be sure that viral contamination does not occur in groundwater, or is not transmitted to the domestic water source as a result of this groundwater recharge.

There are other effects. You heard the speaker this morning talk about gastrointestinal disease from direct reuse. In the case of body-contact sports in the polluted waters, there are risks of conjunctivities and of epidermal reactions. Let me end this list of diseases by saying that, with respect to the blue ribbon committee report and its recommendations, one link that is available but which was not stressed in the report is the link between indices of exposure - specifically, changes of body burden of various materials which can be shown to be present in wastewater streams and the consumption of treated wastewater. These indices may be in the area of chlorinated hydrocarbons. As you know, we have developed a good deal of sophistication in the ability to detect chlorinated hydrocarbons in extremely small amounts. The body burden of some of the heavier metals, cadmium, possibly chromium, lead, and arsenic are those that we have experience with study, although not all of these are going to be in wastewaters or recoverable from groundwater. I think we should make a point of emphasizing that these materials can be analyzed by practical means, and we should stress this.

One area that leaves me somewhat uncomfortable because of its omission, although its a small omission, is that the monitoring program called for is all instrumental monitoring. It does not call for health monitoring, as I have read the report - perhaps Dr. Winklestein will correct me here. I do believe, and this applies to a whole variety of other environmental exposures where the health hazard is a problem and is not clearly answerable, we should not undertake innovative programs without the development and application of a systematic program of epidemiological monitoring.

So with these remarks I will conclude by saying, that there are going to be health risks. It is up to health authorities to work with all of you in trying to better document them. This work isn't going to be done without some resources put into it. At this moment, there is practically no resource input into the health risks evaluation. As long as there is discussion on what should be done, and what will be adequate to protect the public health, it is going to be somewhat academic, but largely bureaucratic. I hope that we will end up with programs which do put adequate resources into the measurement of risks so that their acceptability can be judged and evaluated in the appropriate form. That form is not always the scientific one. With these remarks I thank you for your attention.

(Edited from tape recordings by John M. Toy, Los Angeles City Department of Water and Power.)

BENEFIT VERSUS RISK FROM RECLAIMED WATER IN PERSPECTIVE

Presentation by Dr. Ronald A. Howard,
Department of Engineering of Economic Systems,
Stanford University

Let me very briefly describe what decision analysis is, give you a feeling for where it has been applied before, talk very briefly about some of the problems in the area of risk assessment and risk appreciation by the public, and perhaps end with some recent research that may be helpful in this context.

First of all, decision analysis is the discipline of finding the logical decision implied by choice; that is, what your real alternatives are. A basic element required is information in terms of structural models and relationships usually captured by mathematical models in some form. Also, the degree of uncertainty must be determined, as measured by assessing probabilities on events or probability distributions on variables, or joint probability distributions on those variables. When you have done that, specifically "what you can do" and "what you know," you still have to figure out the most important thing of all, which is "what you want."

The "what you want" has three important dimensions that we try to distinguish. First, there is the "this versus that" problem - how much is an apple worth relative to an orange, or a day in the hospital with pain worth relative to your bank account. The second is time preference. Time preference is the "now versus later" problem - what is a particular outcome in the future worth relative to that same outcome today. This dimension may be very significant in water problems. Lastly, we have the problem of certainty versus risk. We all know about gambling and fair bets. It is a fair bet to double or nothing on next year's income, but I venture to say not many people in this room will do it. So expectation as a measure of risk preference is not adequate, and we have to go to other measures that are more descriptive of the way people really trade off between certainty and risk. This is the bare bones of the profession.

Graduates of this curriculum were used in the private sector in such business-oriented problems as new product introduction or facilities expansion. This direction is about ten years old now. Application got under way in the public sector soon after, which I think is of more concern to this group. A typical example in the area of power system expansion is - should you introduce a nuclear plant to a power system. Also, in planning a space program -

how do you arrange the sequence of vehicles that you fire, and what do you do with them in order to establish a given space mission. More recently in the space program there is the problem of planetary quarantine, which I suppose has two faces. One is the question of how do we keep Mars from having earth bugs growing on it because of mistakes we might have made in our program. As a matter of fact, we have international treaties enjoining us from doing that. The more important problem, which we will face very soon, is how do we plan a space program that might bring samples back from Mars or another heavenly body which could conceivably introduce some bad news on earth.

On the subject of nuclear power safety, you have probably heard of the Rasmussen report. About eight years before Rasmussen, we did our first study of that kind. It was a more comprehensive one which included one of the factors that he was criticized for not including - namely sabotage.

Wildfire protection is another basic safety problem. It is a trade-off between safety and economics - what level of brush clearance or zones is required. As a matter of fact, this very area we are sitting in today is appropriate when you are going to do this kind of balancing.

With regard to hurricane seeding, it has not been scientifically demonstrated, but scientifically indicated, that seeding hurricanes with silver iodide will mitigate their effect. A question is - if a hurricane is headed for the U.S., should you seed it or not. The answer in my opinion is yes.

In the control of automotive emissions, it is a question of market mechanisms versus the kind of regulatory control we have now. A study just published indicates that perhaps we have too much money invested in air pollution equipment and automobiles relative to what people are willing to pay for cleaner air.

The same thing applies with power plant emission control - particularly with Eastern power plants. For example, should they be required to burn low sulphur coal, or should flue gas desulphurization be required. A study we expect to get into fairly soon is the question of the shipment of liquefied natural gas and the attendant risk that might be imposed on the California Coast. Thus, through my quick review, these are the kinds of problems to which decision analysis has been applied.

Now, in the water context, it is basically a trade-off between economics and health. There is a great deal of uncertainty, as we are all aware, in exactly what health effects might be caused by a given quality of water.

One of the problems that we face is that most people have never thought about the risks that they face in going through life. The average person sees himself in a fairly safe situation. If you mention a risk that he hasn't thought about before, he treats it as surprising, and maybe even something to get very concerned about. Just to put things into perspective, you might like to see these typical rates for different problems that people might have - health, accidents, and so forth - per one hundred million U.S. residents. In a recent year for which this was taken you see item number three is botulism. The rate is one person per hundred million, or about two people in the country, that died of botulism. People think they face a great risk from botulism. Psychological research has been done showing that this risk is many times overestimated by the population. They think every tin can is a potential killer, but it is obviously not a major health problem. On the other hand, certain other problems like number thirty, emphysema, took about 21,000 people from the Nation and is not perceived as much of a risk. It is considerably underestimated as a source of human mortality. This is one of the problems that one gets into when people start saying - what about the risk from a hurricane or the risk from an LNG plant. People don't know the risks that they now face. When you talk about a new one, they have no way of putting it into perspective. Just to give you an illustration of this situation, a student came up with a new source of risk which had to do with choking to death on your food in the year. I bet you have never thought about the risk you face from choking to death on your food in the next year. Well, the odds are about one in a hundred thousand. Based upon the Rasmussen number, that is many times larger than the risk that you might die from a nuclear power plant problem.

I also mentioned that I would share with you some of the research that is going on. Some of this research is what we call the value of life, or in other words, how do people trade off between the risk of dying and the economic benefits that they might gain from some proposition. I won't have time to discuss it in detail, but based on this research for a typical student, a typical curve might look like this. Along the bottom axis we have the incremental probability of dying in a particular year, ranging from certainty over in the right down to one chance in ten million over in the left. The upper curve shows how much, based on this theory, you would have to pay a person to take an incremental risk of that size. It goes infinite for this person at about one chance in ten. No amount of money could induce this person to play Russian Roulette, for example, which would have a 16% chance of his dying.

In regard to our public policy questions, the risk of death is of the order of ten to the minus four or less - that is the left-hand side of this figure. What is interesting is that the curve falls off linearly on this logarithmic scale.

The bottom curve shows the implicit value of life that would have to be assigned by this person in order to be willing to accept the additional risk with the probability shown in the upper graph. As you can see, this is about 2.4 million dollars for the whole range of social decision. Such a person when faced with the probability of choking next year, which was one in a hundred thousand, would look at this and say, "Choking to me is like a $24 problem, and I'm going to worry about it about that much." Whereas car accidents, which are about a 1 in 4,000 chance, are like a $600 problem to him, and he might well buy seat belts in an attempt to mitigate it.

The whole point of this discussion is not to in some crass sense put a dollar value on life. Rather, every safety decision requires a trade-off between economics and the reduction of hazard. You have to have some methodology for carrying off that trade-off. If we assigned a value of life that was a hundred million dollars and made all our public decisions consistent with that, then we wouldn't be able to afford a plane ticket to New York. We wouldn't be able to drive on the highways. Life would be just too expensive for us. If on the other hand we assigned it at $1,000, we would be afraid to go out of the house. We would be continually subjected to hazards that we thought were unreasonable. Thus, the question is where in that range might the risk be appropriate.

(Edited from tape recordings by John M. Toy, Los Angeles City Department of Water and Power.)

BENEFIT VERSUS RISK FROM RECLAIMED WATER IN PERSPECTIVE

Presentation by Dr. Warren Winklestein,
Dean, School of Public Health,
University of California, Berkeley

I will keep my remarks very short, since John Goldsmith and I are both epidemiologists and I agree essentially with everything he said. I'll just add a couple of remarks. I would just like to make a few sort of general comments from an epidemiological view of the problem.

It seems to me that, when you are talking about the problems of groundwater recharge, it is exactly the same problem as recharge of surface waters or recharge of the air. There are some qualitative and quantitative differences. When we treat the fluid wastes of our society, it is our habit to discharge the wastes into surface waters. We don't talk about it as surface water recharge, but it is exactly the same thing. The chemical processes may be slightly different, but they are basically the same kind of problems. You put this material back into the water system where, in many parts of the country, you are going to withdraw the water and reuse it.

The problem is as our technology changes, and I would emphasize change rather than necessarily becoming more complicated, we discharge different things into the water supply. Even in Prehistoric times, or certainly in Ancient times, I am sure that we had very heavily polluted water systems from which people drew their water supplies. They were not unaware of the problems in early Roman and Greek times. If one examined the literature carefully enough, one would find plenty of reference to the advantages of taking waters from high places versus low places, based on the reason that the waters taken from the low places tend to be contaminated by human, animal, and industrial waste of those eras. So, we are not dealing with a new problem. We are dealing with an old problem.

The problems appear frequently to be more complex as there are industrial operations that we now undertake, which are certainly more complicated than what the Romans did.

If I had to look at the problem the way Ron Howard looks at it, my guess would be that, if I were living in the Ohio River Valley, I suspect that the risks would be greater to discharge the water into the Ohio River than the risks would be to discharging the reclaimed waste from waste treatment plants into the ground. I think, in order to stimulate the discussion and to give some time, perhaps I'll just end there.

(Edited from tape recordings by John M. Toy, Los Angeles City Department of Water and Power.)

BENEFIT VERSUS RISK FROM RECLAIMED WATER IN PERSPECTIVE

PANEL AND AUDIENCE DISCUSSION

John Goldsmith

I have two comments, and they are largely in response to Professor Howard's views. First, I am a practitioner of the analysis of mortality statistics, and I recognize how handy they are for their unequivocalness. Also, I recognize the fact that you can make comparisons county by county and over a period of time with a certain amount of comfort and validity. I don't feel comfortable in using mortality statistics for risks analysis for the following reasons. I think that most of us do not make decisions in our lives on the basis of very low probabilities of death. We do make decisions in our lives on the basis of comfort, on the risk of being disabled, and especially being socially disabled, whereby not being able to do the things that we feel are important in our role as people. I wouldn't be terribly happy about a comparative risk analysis that is based solely on mortality. As I say this, I recognize that morbidity data, social performance, and disability data is not as available or is appropriately available.

The second position I want to put forward is actually a derivative one. A number of us have done some work on a comparable problem involving air pollution while on the National Academy Panel on Vapor Phase Organic Pollutants from Hydrocarbons. This work was quite analogous to the problem, as Warren so easily put it, of atmospheric recharge of pollution. We have put forward the idea that there are three realms of evidence of risk. Perhaps we ought to consider the applicability of those realms to this problem.

First, there are a set of risks that are so threatening that they require imperative action almost without regard to the cost of taking that action. Secondly, there is a realm of risks in which prudent people would say we want to get the risk down within the acceptable range. But how far we get in down, how fast, and in which community do we have the best situation is something that is quite appropriate to be considered with the trade-off of how much it costs. We also have a realm of exposures within which we do not know of any risks whatever. From the point of view of health within that range, our judgment is we don't care what the level is. An unfortunately large realm exists which we always prefer to ignore. That is the realm of ignorance. There are a lot of things to which we are exposed - things we really don't know what they do and cannot put into any of these categories. I wonder whether this kind of system might not be appropriate here. I would like your comments.

Ron Howard

First of all, I wasn't saying that mortality data was the data on which decisions should be based with respect to the water supply. It would be wonderful if we had enough data to do all kinds of things in the world, but in general, we don't. The question is - how to do something logical and reasonable in the face of the information that we have. Man has always had to act with less information than what he wanted, and to some degree, the decision analysis procedure that I am describing is exactly the response that is needed to act when you don't know what is going to happen. As a matter of fact, the whole language of probability was happily developed a few hundred years ago, so we would have a way of describing exactly what we mean by uncertainty. Yet people seem to avoid using that language. They prefer to talk about hazards and risks, when in fact reducing it to the probability language would make clear exactly what they are talking about.

The issue of adding other dimensions to outcome besides death is one that was to be my final comment. If I had more time, I would have presented a list which includes not only death, but pain, scarring, bereavement, property losses, and so forth. It is very interesting when you ask people the value of life questions and you find out just how different they are individually. For example, cosmetic effects. Some people would willingly incur very large amount of pain to avoid scarring. Other people are virtually indifferent to scarring if they can get out of the hospital quicker. So there is a great range of difference, and I think that is good. I think we are talking about a methodology that any person could use for his own decision, and it is only when we come to the social decision realm, that we have to develop a procedure that trades off one of these outcomes for another one.

I think, regardless of what philosophy you might have with respect to making these decisions, the real test comes down to methodology. If several people have a methodology for making a decision on proper treatment of water, then let us get them out. Let's try them all, compare them, see which one provides the greatest insight, and see which one is consistent with the information available, keeping in mind the preferences of the people that have to be considered.

My concern is that no methodology has been proposed besides the one that I am proposing that handles all these things in a logical framework. I wish there were, because then we could take the best features of the competitors and combine them with this. But there is none, and so you have the choice - you can have it done by human intuition, when human intuition has been shown to be very poor in making probabilistic judgment and very inconsistent in deriving values based on complex value structures - or you can do it in a way that is in the open, where everybody can see the numbers, where it is checkable, where we can argue about probabilities or values and finally arrive at a decision that balances those things. To me it is a very simple choice.

Warren Winklestein

I would like to get the discussion back to water. I was tempted to move it even further away. I guess the decisions are probably made on other basis than the technical grounds of disease risks. A case in point is the fluoridation of public water supplies. A procedure has been established, tested, and shown to have tremendous efficacy. Its benefits are very great, and its risks are close to zero. There has been some scare literature, but there isn't anything very solid. Here in California we rank 46 out of the 50 states in percentage of public water supplies which have controlled levels of fluoridation. The decision is obviously not being made on the benefits. The Governor won't take a position on this, and he won't permit the Director of Health to take a position, although the State Health Department had a position for twenty years. Here we are in a conference discussing risks from groundwater recharge. We have all around us ever present risks from surface water recharge. I am unable to give you any easy way out of these kinds of dilemmas. I would like to reinforce what John Goldsmith said about the need for more understanding of these issues. There is very little resource being fed into a better understanding of the technical problems, the social behavioral issues, and the disease risks. It may be the attitude of the public and the Government now towards not trying to get new information but to apply what we know. What we don't know is gigantic.

Coming back to the subject of water, the problem of reclaimed water is a general one which requires a lot more research. I don't see why putting into the ground is potentially more dangerous than putting into the surface waters.

John Goldsmith

As I understand the epidemiologic ability that exists in our Department, in Dean Winklestein's school, and in the country as a whole, it is time to define it as extending beyond disease frequency and into areas of measurement of health impairment, annoyance, acceptability, and the fear of hazard as well as the actual occurrence of disease. I feel that the capability is there, but it has not been applied to these problems.

Audience Question

Nitrates are thought to have health effects when they exceed 45 milligrams per liter. The corresponding concentration of stable organics is much lower than that. Why are we paying so little attention to nitrates, which are relatively high and about which we know a great deal?

John Goldsmith Comment

We are paying attention to them, and I simply want to indicate that I am concerned. As many of you know, there is a very large-scale groundwater recharge program in Israel. The buildup of nitrates in their groundwater has been a problem and was evaluated because of health implications. It is very difficult to get the nitrate out of the groundwater once it is there. It is far easier to keep it from getting there. That is one of the reasons why I expressed the concern.

Stable organics are, at this moment, poorly characterized with respect to their effects on health on diseased states. They are not so poorly characterized with respect to their effect on health on some other systems. As long as we are engaged in a national debate about the carcinogenic hazards of extremely low concentrations of many materials, we are going to have to move with great care. The public expects this of us and we are going to use the best judgment we can.

Audience Question

We know that exposure to the human is much more through food rather than from water. Are we not concerned too much with the water concentrations? Also, what is the exposure to humans where irrigation is carried out with the reclaimed wastewater with the resultant effect of certain substances being accumulated in the food crops?

Warren Winklestein Comment

I think that we are as concerned about the potential of food as a vector for disease-producing agents as we are about water and air. I'm not sure whether I agree with your premise. It seems to me that we don't know very much about the mechanisms for disease production. We talk about nitrosamines or organic compounds, and yet, the evidence for their disease-producing effects in humans is inferred, largely from animal experiments. I don't mean to suggest that these are not very important potential disease-producing agents. I believe that we have to treat them as such. We can't consider them innocent until proven guilty, but have to turn it around and be extremely cautious and suspicious.

John Goldsmith Comment

I would like to respond lightly to this question by saying we all recognized the differential ingestion from water and food, but very often, on a simple metric basis, food seems to be dominant. We have done virtually no work to estimate what the ingestion is of inorganic or organic constituents in water when there is a difference in water quality. We don't know whether the beverage processing adds or detracts from the gradients in mineral content in water to an adequate extent. These are rather simple things to do, and we have not done it.

But research has shown that what seems to us to be quite small differences in ingestion, inferred differences from water concentration appear to be associated with rather drastic changes in these rather common ions in body tissues. So, we have got to be a little careful about dismissing water as a source of ingestion just because it is modest compared to food on a mass basis.

We do know that some of the pesticides are stored in root crops. An example of this is chlorinated hydrocarbons in carrots. We also have a rather disturbing, but quite unequivocal, documentation of the relationship between lead arsenate used in soils in certain areas and the continued contamination of the tobacco grown in those areas for over a decade after that arsenate was no longer used. I recognize these aren't questions of necessarily wastewater reuse. It is perfectly obvious that most of the history of agriculture is the history using manure or night soil for fertilization. I recognize that industrial wastes are not in the same category as manure; therefore, we should be carefully monitoring the inorganic metals and the radioactive isotopes. In regard to the use of the reclaimed water for agriculture, we have always been in an encouraging posture in getting that reclaimed water use implemented. I believe that the questions the Health Department will raise will be focusing on industrial wastes and not domestic wastes.

Audience Question

I was wondering Dr. Howard if you had had an opportunity to estimate any of these types of risk information related to the proposed "groundwater recharge by reclaimed water" regulations?

Ron Howard Comment

I looked briefly at the regulations, and what struck me was that it was a control of process as well as product. This seems a bit strange, in that either one can control the process and then live with the product or you can control the kind of product you want and then let people choose whatever process they want to produce that product. To control both is usually very expensive and very uncommon in most situations. Also, it appears that an analysis was not done to tell us the risks associated with the kind of water that might come through a more limited kind of treatment than the one proposed. My impression of the so-called blue ribbon panel - not just the people on the panel, but the people that we met who were responsible for the decision making - is that they don't do analysis of this kind. I think this is a tragedy because in other areas, such as space or nuclear power, we have large bodies of people who are talking in terms of probabilities and the value of increasing or reducing a probability. Before California spends billions of dollars to make changes in the water supply systems, I would want to see a very careful study of risk, benefit, and hazards of these proposed changes.

Audience Question

Dr. Howard, if we go to water reclamation with very stringent standards, then are we not going to consume a lot of energy and a lot of money, with the spending of that money interpreted as a degradation of health since we could not spend as much on health care?

Ron Howard Comment

Money is just another name for a resource. Energy is a form of resource really no different from any other kind of resource that costs money. The basic thrust of my argument on the question of safety is that it is a basic trade-off between mitigating something you don't want and spending money to do it, with the resultant diversion of other resources. That's the name of the game. I just don't see that trade-off done here. Somebody comes to me and says, "Mr. Taxpayer, you and your friend spend another million dollars on the water system to make it safer." They don't tell me what is my reduced mortality risk. I might prefer not to have it spent on the water system, which I might consider to be safe enough already but elect to have it spent on some other reduction of risk (i.e., nuclear). That is bothering me the most at the moment.

John Goldsmith Comment

I agree with your philosophy and your strategy Dr. Howard. But, we're not just talking about spending a great deal of money on a water system. We're also talking about how to determine what is a socially constructive way to apply some new practices to the operation of this water system. We have to get information in order to work on these probabilities. Right now, we don't have the basic information we need. I would like to put before this audience the proposition that if you're telling us in the Health Department that these are going to be very costly regulations, then I believe this statement justifies the expenditure of a small amount of money to get some of the basic data that will permit us to develop probability statements before the regulations are fully applied.

Ron Howard Comment

I wanted to comment on something that Warren said earlier about the fluoridation. The logic that we are talking about may not be done by the scientist. It is perfectly possible to incorporate any preference the public might have. There are people out there who worry about putting things in their water supply. They say it might be worth a hundred dollars not to have holes in my kid's teeth but it is worth five hundred dollars not to have somebody fool with the water supply. It might seem irrational to a scientist, but it is an acceptable social value judgment as far as I am concerned.

We could put two glasses of water on the table where one is guaranteed to be scientifically equivalent to the other. One is reclaimed and one comes from Hetch Hetchy Reservoir. Which one is the guy on the street going to drink if he has to pick one? The people who design the water supply system may be perfectly happy to drink either one. But try that on a man in the street. That is your so-called acceptability question. It is the premium that they are willing to pay that really determines what kind of social choice can be made. The premium may be reduced over time as the opinion leaders get into the act and as the public learns that there is really nothing to worry about. These are the actions that are going to determine the rate in which this whole movement can proceed.

(Edited from tape recordings by John M. Toy, Los Angeles City Department of Water and Power.)

CRITIQUE OF DISCUSSION GROUPS

Moderator

Linda K. Phillips - Goleta County Water District

. DUAL LINES - AVALON, CATALINA ISLAND

By

George Crum - Southern California Edison Company (Edited from tape recordings by David Ringel, Los Angeles Department of Water & Power)

. BASIN RECHARGE - WHITTIER NARROWS

By

Robert P. Miele - Sanitation Districts of Los Angeles County

. CREEK DISCHARGE AND IRRIGATION - LAS VIRGENES

By

M. E. Ford - Boyle Engineering, Ventura

. INJECTION TO REPEL SEAWATER INTRUSION - ORANGE COUNTY AND SANTA CLARA COUNTY

By

Nereus Richardson - Orange County Water District (Edited from tape recordings by David Ringel, Los Angeles Department of Water & Power)

Presented at the Third Annual Conference, WATERCARE, "Conservation Through Reclamation", June 10-11, 1976, Pepperdine University, Malibu Campus.

DUAL LINES

AVALON, CATALINA ISLAND

by

George Crum

Southern California Edison Company

Once again, I am talking about water reclamation to a group that knows lot about it, and I don't know anything about it. We at Edison are in the electric business; however, we have been in the water business in Catalina for fourteen years now. Back in 1962, for some reason we took over the water, gas, and electric utilities on the Island of Catalina, and we have been playing games with them ever since. For those of you that are not familiar with Catalina or have not been there recently, Catalina is the island that part of the time yesterday you could see lying off the coast out here. It's about 35 square miles; it has a full-time population of around 1,600 people. That population swells up to about 17,000 during the summer. It is primarily a resort community - which means that for about three months out of the year they have a lot of activity - and for nine months out of the year everything kind of dies.

The island has always been very water short. Back in its history, during times of critical water shortage, they have barged water to the island. Shortly after we took over, the system had a small catch basin reservoir on the far side of the island. In order to operate during a dry year, we installed a seawater conversion plant having a capacity of 100,000 gallons a day. This plant kept us from having a critical water shortage for one year. The plant is no longer in operation and has been removed because of deterioration.

Since we have been on the island, we have increased the size of the reservoir to a capacity of 1,050 acre-feet. To give you an idea of the size of the utility we are talking about, our sales for last year were approximately 400 acre-feet of freshwater. In addition, in the City of Avalon, separate from the freshwater system, a seawater toilet-flushing system, which is also used for fire suppression, has been in use for some time. For many years there was an ordinance that required separate plumbing facilities and separate service for toilet flushing.

Back in about 1967 or 1968, we raised the height of the dam and increased the size of the reservoir which presumably was going to solve the water problems on Catalina for a long time. The only thing we forgot is that sometimes it doesn't rain. The ordinance for a separate water system was eliminated at that time. So, any structures that have gone in since then only had a single water service. The water shortages have occurred, and we now are facing quite a bit of growth on the island. Some 700 units are either under construction or are in advance stages of obtaining permits. We simply do not have enough freshwater to supply these additional needs.

We had to do something to expand our water supply. We looked at developing another watershed, but the cost involved was very high and the water available is very limited. The cost of developing another watershed would be around $10,000 per acre-foot per year. We looked at installing another seawater converter; but at the time we originally operated the converter, our operating costs were in excess of $4.00 per thousand gallons, and that was on fuel that cost one-third of what fuel costs today. This means it would cost somewhere around $12.00 per thousand gallons to convert seawater today by the same process. We decided that wasn't very cost-effective. We also looked at barging water which would cost us around $12.00 a thousand gallons. Even though we sell water at $1.75 per thousand gallons, you don't make much money when it costs $12.00 to produce it.

About the same time, the city was mandated to put in a sewage treatment plant to eliminate the discharge of raw sewage into the ocean. The sewage treatment plant, designed by Engineering Science and built by Newmann Construction, has just been completed and is owned by the City of Avalon. The original plan was to discharge secondary treated wastewater into the ocean. It occurred to us that perhaps we could solve our water shortage problem by utilizing effluent from the sewage treatment plant for toilet flushing in place of salt water, reinstall the ordinance requiring separate plumbing facilities inthe houses and in these new structures to be built, and cut down the amount of additional freshwater that we were going to need. Feasibility studies indicated that this proposed system was cost-effective and there would be enough water provided we replaced salt water in the separate system with freshwater during a transition period and thereafter used reclaimed water for that purpose.

The State Health Department bought the idea provided the water received tertiary treatment by groundwater recharge prior to reuse. I was asked last night in the session how far our extraction wells are from the percolation ponds. The nearest extraction well is about 1,000 feet from the percolation pond and the farthest one is about 1,600 feet.

We have now built a system on Catalina to take the water from the outfall line from the sewage treatment plant up to the upper reaches of Avalon Canyon, put it into percolation basins and let it percolate underground. After recharge of this small aquifer, which has a capacity of about 300 acre-feet, the water is extracted downstream and introduced into the existing salt water distribution system for toilet flushing and fire suppression uses. It will still be a separate service. Because it does go inside individual homes, it must be certified to be potable water by the State Health Department; but it is not certified for human consumption. I am not quite sure what that distinction means; however, that is the conditions of the permit.

We have not yet gone into the reclamation business. The City of Avalon will probably act on June 21 to authorize the bill-of-sale transferring the saltwater system to us. Presumably, on June 22, we will become the operators of their sewage treatment plant and will be responsible for the saltwater distribution operation. Our plan at that time will be to continue operating on salt water until the winter months when the toilet-flushing consumption will be at the lowest. Then we will use freshwater during this transition period for about three months to purge the system of salt and recharge the aquifer. So, by next February or March, we should have this reclamation system in full operation. Any of you who would be interested in taking a look at the system, either now or after it is in full operation, I would like to have you come over to Catalina - I think it will be a pretty good laboratory-type demonstration project.

We do have one problem in connection with this operation. The State Health Department has included as a condition of their permit a requirement that a suitable backflow device be installed on the freshwater system for all structures equipped with dual systems. The State Health Department went on to say that so far as they were concerned, a double-check valve was a suitable backflow device and would satisfy their requirement. There are currently about 400 some structures now using salt water and some 700 structures that have piping for dual systems, none of which have backflow devices. Backflow devices never have been required to protect the freshwater system.

On the other hand, the County of Los Angeles says in their interpretation a suitable backflow device is a reduced pressure backflow device. There is a cost differential of about two to one betwee an RP and a double-check valve device; but more than that, we have a major problem with installation. An RP has to be installed above ground. When Avalon was originally developed, the lot size was 20 by 40 foot with the houses going to the lot line on all four sides. As a result, there is no physical place to install an RP above ground unless we put it inside the living room or up on the top of the house. Since you have to service them once a year, these locations are a little impractical. Some of the water services are on the alley side. We could put the devices in the alley, but we would encroach in a ten-foot alley which could be hairy when you are running garbage trucks down the alley. So, there are some real installation problems. That was the problem we kicked around the room last, and needless to say, we did not really solve the problem, especially since the County representative was not there.

We did get some suggestions, though, of things we might do to try to resolve the problem with the County. One suggestion made was to maintain a pressure differential between the freshwater and the reclaimed water systems, and run the freshwater system at a higher pressure at all times. That would eliminate the need for any kind of backflow device. If there was an inadvertent or an intentional cross-connection in a house, the water would flow from the freshwater to the reclaimed water side and not vice versa. That seems like a good solution. Since this water is potable water that is not certified yet because it can't be proven safe for human consumption, it seems to me the health risk is fairly small and should provide adequate protection. We may try to convince the County of this to get them to relax their requirement.

Another suggestion was that we seek a two-year waiver to defer installation of the backflow devices, subject to some extensive monitoring and reporting of this maintenance of pressure differential to see if we could get the County to relax their requirement of installing the RP's until it was demonstrated that there was a real need for them. I don't know that either of these solutions are going to be acceptable, but I think we can pursue them.

There were several other things discussed last night, but these seemed to be the two suggestions that held the most merit for us. That's been a fairly brief resume of what our project is about and our very lively discussion session. I appreciate very much having those who did attend take such an active part in it.

Again, if any of you would like to come cover and visit the island, don't come during the summer - that is when everyone else comes. The island is beautiful in the off-season, and we need some more business then. So, if you would like to come over in the off-season, we would be very happy to show you the various systems.

(Edited from tape recordings by David J. Ringel, Los Angeles City Department of Water and Power.)

BASIN RECHARGE - WHITTIER NARROWS

by

Robert P. Miele

Sanitation Districts of Los Angeles County

As indicated, our subject last night was basin recharge with reclaimed water and it should come as no surprise to anyone that the discussion very quickly centered around the State Health Department's proposed regulations for groundwater recharge by surface spreading with reclaimed water. So what I would like to do, rather than talk about Whittier Narrows and what happens at Whittier Narrows, is to summarize our discussion last night relating to these particular proposed regulations. I know many of you will be offering your own comments about these regulations at the hearings the Health Department is having and thus I'll try to give you the collective benefit of our wisdom. My summary will not be nearly as inspirational as Will Stokes' "Sermon on the Mount" that you all heard yesterday. Will often has a tendency to shed more heat than light on subjects--so maybe I can help him. For those who were here yesterday and who aren't familiar with the regulations to which I refer, let me summarize very quickly what the group saw as the important features of them.

First of all the regulations require activated carbon and reverse osmosis treatment of all wastewater that will be used to recharge groundwaters by surface spreading. In addition to that there is a numerical limit on COD; the average COD shall not exceed 2 per liter. The regulations also require a minimum vertical distance of 20 feet between the surface and the groundwater table. Also there is a minimum time period of one year prior to withdrawal from a community domestic water supply well.

Our group tried to identify what we saw as problems associated with these proposed regulations and then attempted to recommend some potential solutions. We did a very good job of identifying the problems. The solutions weren't quite as clear to us. In the middle of our discussion, George Adrian mentioned the old adage that a "fool can ask more questions than a wise person can answer"--which didn't do muct to stimulate further discussion!! Let me start by identifying some of our questions and concerns relating to the proposed regulations. First of all, and Rev. Stokes mentioned this yesterday, there is a concern as to why reclaimed water is being singled out by these regulations. It was pointed out last night that other waters of the State have COD values greater than 2 milligrams per liter, and yet the proposed regualtions are not applied to these waters but only to reclaimed water. Also, the proposed regulations are sort of dual in nature in that they not only dictate the quality of water desirable but also describe how it must be achieved, and there was concern expressed last night as to why that had to be so. It was clear from last night's discussion that these regulations, if they are adopted as is, would result in treatment cost which, in our opinion, would eliminate any future groundwater recharge with reclaimed water. The County Sanitation Districts have been doing research for about 10 years on activated carbon. We've also done research on reverse osmosis. It is our best estimate that the cost of activated carbon plus reverse osmosis on treatment plants in the size range of ten to twenty million gallons a day would be in excess of $200 an acre-foot. That certainly puts water reclamation out of the picture in Los Angeles County--just from a cost standpoint; and I can't conceive of too many communities in this state where reclaimed water would be an attractive alternative at that cost. Bill Jopling mentioned yesterday that the Basin Plans' projections estimated a 276,000 acre-feet of groundwater recharge by reclaimed water in the future. He also pointed out that at present there were only 24,000 acre-feet per year being reclaimed by surface spreading. This data clearly indicates that if the proposed regulations are adopted, 90% of the potential groundwater recharge with reclaimed water in this State is going to be prohibited because of cost.

Another real concern to those of us who are presently participating in groundwater recharge programs is the effect these regulations might have on existing operations. The regulations state very clearly that they are not intended to apply to existing situations; but, envision for a moment what would happen if these regulations were adopted as proposed. I can conceive of a person who is extracting water from a groundwater basin in the Central Basin where reclaimed water is used as a portion of the recharge water looking at these and saying to the Health Department, "Why have these been adopted?" The Health Department I assume, would have to say, "Because this is what we feel is required to protect the public health of this State." That person would then have to say, "I'm concerned about my public health also, and why do these not apply to me?" And so, very conceivably, that pumper will then go back to those of us who are involved in the recharge operation and say, "Look, if this is requir-d for the public health of everyone else, I want it to be required for me too." Thus, these regulations could very definitely have the effect of terminating not only future projects, but existing ones.

We also had some "technical" concerns about these regulations. There appears to be no credit given for treatment by the soil of wastewaters which are applied to it; there is no credit given for dilution with other imported water prior to spreading. Studies were done at Whittier Narrows back in the early '60's when that facility first went on stream in which we developed test plots, put reclaimed water on these test plots and did sampling throughout the test plot down to about 10 feet. It was clearly demonstrated that there is a rather large reduction in COD by percolation on an intermittent basis in which the basin is filled, allowed to drain, and reaeration of the soil occurs to keep it aerobic. The regulations give no credit for that phenomenon. There appeared to be a great deal of inflexibility in these regulations as they are presently proposed. The concept of 20 feet distance to a groundwater really doesn't take into account the fact that there could be situations in which 20 feet isn't nearly enough or that 20 feet is far too much. The one-year detention time again is obviously an arbitrary standard.

Now, as we went from these questions into some potential paths towards a solution, we sait things like--"there is clearly no scientific evidence for establishing either treatment or quantitative standards at the present time." I think we would have to acknowledge that there is circumstantial evidence that exists relating to the concern about trace organics in waters--not only wastewaters but waters in general. There has been data developed on test animals with very high dosage of organics and we are familiar with the concern in New Orleans about cancer related to drinking water. Given the circumstantial evidence, we didn't quite see how we move from that into these very stringent standards. What the circumstantial evidence does suggest, and the group last night clearly endorsed, is the fact that the need exists for research work to be done, commencing immediately, that tries to define the problems associated with groundwater recharge with reclaimed water. We have to develop dose-response data for particular organics. Some of this work is just beginning to get under way, and I think the State Health Department and the State Water Resources Control Board and everyone else involved in this has got to make a commitment of resources to identify the problems and then lead to some rational solutions.

Research that we are talking about would include monitoring of the input and withdrawal from the recharge basin. It would include some type of hydrogeological studies to identify where the water is going and so on, and most certainly we would have to do some type of epidemiological studies.

The suggestion was also made that research should commence immediately, aimed at looking at other methods of removing ogranics from wastewater that might be less energy and cost intensive than activated carbon and reverse osmosis. I definitely think that work whould also be done.

WATERCARE has endorsed the concept of single water quality standards for all sources of water. This is what I heard last night too. If we are going to adopt regulations such as these, then perhaps they should be on all waters and not simply reclaimed water. Or, moving one step backwards (at least as it relates to groundwater basin recharge) perhaps we should put these standards on the water being pumped out of the ground and not the reclaimed water which represents only a portion of the water going in. The question was raised then: "Well, what happens if five years or so from now we find out that the water we have been putting down there has materials in it which are harmful?" A potential solution to that problem may be to then apply activated carbon and reverse osmosis treatment to the water coming up out of the ground. This would at least give the operators of groundwater recharge systems more flexibility in coming up with cost-effective solutions where they may determine that it is more cost-effective to treat the waste-water before it goes into the ground, or that it is more cost-effectiveto allow dilution and soil treatment to occur and treat it when it comes out of the ground.

There is some concern about the value of the COD limit listed in the regulations. Most of us felt that there should not be any COD limit al all because we don't know what to set it at. As you know there are 20 organic compounds listed in these regulations that have to be monitored. We endorse the concept of monitoring these organics both in groundwaters and in wastewaters being applied to the ground and as dose-response data becomes available perhaps we can then set standards on those specific compounds which are identified as a problem.

If I can generally summarize what our recommendations were--I guess they would be threefold. First, we would recommend immediate commencement of research aimed at identifying solutions to the problem of trace organics in waters and wastewaters used for groundwater recharge operations. Some of this research is, as I mentioned, ready to begin or is already under way. The Orange County Water District has been doing a little bit of this work and has proposals to do further work. The Los Angeles County Sanitation Districts are developing a proposal that would involve an extensive monitoring program in the Montebello Forebay. Santa Clara has research planned that would begin to provide answers.

Secondly, we recommend that the State Health Department develop interim regulations that are based on present practices which would allow evaluation of recharge operations on a case-by-case basis.

And then, thirdly, as the research work begins to provide results, these interim regulations can begin to evolve into long-term regulations that truly reflect the problems that have been discovered and the potential solutions to these problems.

I mentioned we were able to identify the problems a lot easier than the solutions. I think I reflected that in what I have said. A number of people who were in our group last night are in the audience and if anyone feels that I misrepresented them or that there is something I missed, I'd like to provide an opportunity for their comments now. Or anyone else who would like to reflect on the regulations is invited to do so. Thank you for your attention.

LAS VIRGENES - CREEK DISCHARGE AND IRRIGATION

By M. E. Ford, Jr.

INTRODUCTION

The subject at hand brings to mind that old enigma - the immovable object and the irresistable force. The irresistable force is the continued flushing by a growing population and their propensity to pursue modern standards of personal hygiene. The immovable object is a dynamic duo composed of the environment and the regulatory agencies. Actually, the environment is controlling and the regulatory agencies are merely reacting to the constraints imposed by the environment on any new situation.

In Las Virgenes the environment has been particularly difficult relative to reclamation and re-use of wastewater. There is not an abundance of agricultural land or greenbelt area to present a demand for reclaimed water. There is virtually no ground water regimen to provide a water spreading opportunity, and even if there were, it is doubtful if current Public Health Department philosophy would permit such a program. The area has no industries that offer a re-use potential. In addition, the Las Virgenes outlet to the ocean is Malibu Creek and Lagoon, as sensitive a route as one could find.

In spite of all this adversity, the Las Virgenes Municipal Water District, under the leadership of a forward thinking Board of Directors and General Manager and Chief Engineer, H. W. Stokes, has pursued a program of reclamation and re-use of wastewater. They have done the first thing needed for a viable program for reclamation and re-use — that is consistently producing a superior effluent meeting stringent requirements. Further, they have persisted in research and development and the advancement of new ideas. Like other pioneers in our land, a few arrows have come their way.

TAPIA WATER RECLAMATION PLANT

The Tapia Water Reclamation Plant of LVMWD presently processes on the order of 4.6 MGD of wastewater generated in the Triunfo-Malibu-Las Virgenes Creek watershed. In addition, wastewater from the San Fernando Valley area within LVMWD is transferred to the plant. Current estimates indicate that wastewater flows could be doubled by 1980 and be as high as 15 MGD by 1990.

Some of the significant parameters of the Tapia reclaimed water are:

Constituent	mg/l
$B.O.D._5$	3
Suspended Solids	3
Total coliform	less than 2.2 MPN/100
Nitrate Nitrogen	14
Ammonia Nitrogen	0.6
Phosphate	30.
Turbidity	less than 1 TU
T.D.S.	800-850

To achieve maximum re-use of their reclaimed water, the District has worked toward a program of irrigation integrated with land disposal and creek discharge. Currently the physical paramaters of the re-use program are:

1. Creek Discharge

   Permitted by NPDES permit from November 15th through March 15th annually for reclaimed water not applied to land.

2. Land Disposal

   a. Waste Spray Irrigation

      (1) Available land - 275 acres±
      (2) Average application rate - 23 af/ac/yr

b. Percolation Ponds

(1) Gross land occupied - 7 acres ±
(2) Percolation rate - 1.2 MGD

3. Irrigation

Water for irrigation of alfalfa and other seed/fiber crops in Las Virgenes Valley has accounted for 13% of current annual plant flow.

CREEK DISCHARGE

Creek discharge has been vigorously opposed by downstream interests along Malibu Creek. As pointed out above, the NPDES permit allows creek discharge only during winter months and only to the extent that reclaimed water cannot be applied to land in the area of the District's Reclaimed Water System. Hearings before the Los Angeles Regional Water Quality Control Board relative to creek discharge have been stormy and expanded discharge has generally been denied on the premises of threatened proliferation of algae in the creek system and possible adverse public health effects of the reclaimed water. The State and County Public Health Departments have opposed the discharge of reclaimed water from the Tapia Plant to the creek on the basis that the water does not meet the portion of the body contact standards of Title 22 of the California Administrative Code requiring coagulation, sedimentation and filtration. They have strongly recommended either the additional treatment specified in the code or an ocean outfall. Notwithstanding this, the regulatory agencies have not seen fit to post Malibu Creek and Lagoon and have admitted that it would be very difficult to establish a contamination resulting from creek discharge by Las Virgenes, should such be required in a court proceedings.

The issue of algae proliferation in the creek system has been facing the District since 1969 when the Regional Water Quality Control Board precluded further creek discharge because of threatened algal proliferation. Since that time the District has conducted extensive creek sampling and studies including radioactive tracer studies to attempt to determine the magnitude of nutrient uptake and algal proliferation caused by its releases. By illustrating to the Regional Board that algae are generally dormant during the winter season, the current NPDES permit allowing limited wintertime creek discharge was obtained. It is anticipated that further study will provide the answers needed to resolve this problem.

As wastewater flows increase, the limitations on the ability to dispose of reclaimed water on land within the Las Virgenes MWD will require an outlet to the ocean. The general parameters of acceptability and cost effectiveness along with potential adverse effects of creek discharge at increasing levels of flow must be carefully studied in order to develop the optimal program for this means of continuing with the reclamation and re-use effort of the Las Virgenes Municipal Water District. It is noted that creek discharge at the Tapia facility was anticipated and discussed with the Basin Plan for Basin IV-B. Therefore, this program is not inconsistent with the water quality objectives of the State of California.

On the other hand, the Areawide Facilities Plan, currently being prepared under a Step 1 Grant for LVMWD, has not been able to consider expanded creek discharge because of inability of the District to obtain actual or probable all year creek discharge standards from the Regional Water Quality Control Board upon which a process improvement project can be predicated.

This dilemma threatens to force the Las Virgenes Municipal Water District into premature construction of an ocean outfall and should this occur, it is probable that reclamation and re-use will suffer an economic disadvantage for many years to come in the Las Virgenes MWD.

IRRIGATION

Irrigation and/or land disposal has been limited by available land within reach of the District's reclaimed water system in the Las Virgenes Valley. Much of this land formerly owned by 20th Century Fox and Bob Hope is now owned by the State and is under the jurisdiction of the Department of Parks and Recreation. The status of use of this land for waste spray irrigation is subject to review annually by Parks and Recreation. Should their plans for the area preclude use of this water in this or any other manner, 101 acres will be lost to the District. This has already occurred to 57 acres. Expansion of the reclaimed water system and development of additional areas for re-use are under study by the District to protect their disposal capability against this eventuality. Development of their percolation ponds along Malibu Creek is a result of this effort. It should be mentioned that Pepperdine-Malibu, where we are meeting today, is cooperating by irrigating campus areas with reclaimed water from Tapia.

SUMMARY

It can be seen that the program of the Las Virgenes MWD for reclamation and re-use of its wastewater is in the balance. Whether or not it can move ahead will be decided by the attitude and dedication of the public and government to the philosophy that water reclamation and re-use is, as our laws state, in the highest public interest. Organizations such as Watercare will play an important role in the development of this attitude and dedication.

Nothing worthwhile ever comes easily. Therefore, it follows that water reclamation must be worthwhile.

INJECTION TO REPEL SEAWATER INTRUSION -

ORANGE COUNTY AND SANTA CLARA VALLEY WATER DISTRICTS

By

Nereus Richardson

Orange County Water District

I will first present a brief summary of the situation on seawater intrusion. In the State of California today, there are 13 major groundwater basins along the coast that are experiencing seawater intrusion. If you add up the total amount of groundwater that is stored in these basins, you come up with over 120 million acre-feet of water. As Bill Jopling pointed yesterday, the State's current annual use right now is about 38 million acre-feet a year. So, in other words, there is about three years' supply for the entire State in these basins that are experiencing seawater intrusion, and so I think on that basis alone something should be done to stop the seawater intrusion in these basins.

The group we had was in general agreement that we do have a complex problem; but that is as far as we got on solving it.

There are some interesting correlations between Santa Clara's and Orange County's recycling project. In Santa Clara Valley they have a system that is running just opposite of what we have in Orange County. They inject on the seaward side and extract on the landward side; whereas we extract on the seaward side and inject on the landward side.

The Santa Clara Valley Water District system was designed so that the injection water is intercepted and extracted so that theoretically none of it travels inland. Our system is different from that. Also, there is major difference in the Santa Clara Valley system in that they are injecting into an aquifer that has been ruined by seawater intrusion and has been declared nonpotable; whereas, in the Orange County system, we are injecting into a potable water source.

We find there is a common ground in obtaining all the necessary approvals, including local, State, and Federal permits. It takes about three years to get all the necessary approvals for projects like these. We both have a common knowledge of people in the Health Department; we have met them. Another interesting part of these projects is that both of us are forced into doing extensive research work because there are a lot of unknowns in what we're doing. In the Santa Clara project, they are getting ready to start a $1,500,000 research program on organics, heavy metals, and toxic constituents. We in Orange County have a program involving well over $100,000 on organics, heavy metals, and viruses.

Among the main problems that we have in our district are equipment problems. Most of the equipment in the water business is designed for water treatment systems or sewage treatment systems. When you go into tertiary treatment you're in a land which is a little bit different. Specifically, we have problems with centrifuges; they don't seem to work right; and I suspect that anybody who works with centrifuges think they don't work right. We also have problems with conveyor systems which transport the spent carbon back to our carbon regeneration facilities. We have had to build our own system more or less by modifying the original system.

We also have problems with nitrogen removal. In most designs your goal is for a minimum of 90% removal of nitrogen. On initial startup, we were only getting about 50% nitrogen removal. Now we have worked on plugging up the leaks, and we are around 65% remvoal. Maybe, if we really keep working on it, we might get up to 75 - 80% removal of nitrogen, at the best. But that means we have to finish off our nitrogen removal with breakpoint chlorination.

Another big problem we have is in the area of water reclamation criteria. The criteria that were presented yesterday were for surface spreading only. As a result, for an injection system we have to anticipate what the requirements will be tomorrow. This creates a problem. When you go into any kind of wastewater reclamation program, it involves a big selling job. It takes many years to develop the confidence of your local people that this program is what you should do. Then, if the requirements are changed after you get into it, the project that started off costing $2,000,000 is suddenly up to $5,000,000, and then it is up to $10,000,000. And your local people lose confidence in your decisions. You always have some people who don't like the project to start with; so, when the project cost doubles or triples, they really don't like it.

Another problem is in the area of monitoring. It has been mentioned that the monitoring for trace organics is extremely expensive and, in fact, there may not even be any labs that can do it in California. At least there are very few. When you're in a position like we are in Orange County and they are in Santa Clara Valley, the burden of monitoring for all these constituents are placed directly on you and become part of the project cost.

(Edited from tape recordings by David Ringel, Los Angeles City Department of Water and Power.)

ENERGY REQUIREMENTS OF ALTERNATIVES IN WATER SUPPLY, USE AND CONSERVATION

By

Robert M. Hagan, Professor of Water Science and Extension Environmentalist (Land and Water Use), University of California, Davis, California

and

Edwin B. Roberts, Staff Research Associate, LAWR: Water Science and Engineering Section, University of California, Davis, California

Presented at the Third Annual Conference, Watercare, "Conservation Through Reclamation", June 10-11, 1976, Pepperdine University, Malibu Campus, Pacific Coast Highway and Malibu Canyon Road.

ENERGY REQUIREMENTS OF ALTERNATIVES IN WATER SUPPLY, USE AND CONSERVATION

by

Robert M. Hagan and Edwin B. Roberts

INTRODUCTION

Since widespread concern over water shortages, water pollution, and other water problems preceded the "energy crisis", some recommendations being made by agencies, environmental groups, and others calling for various water supply and management approaches are still giving little attention to energy requirements. However, rapidly growing concerns about the availability of energy and its price are making many earlier planning decisions obsolete. Planners and decision-makers are now much more concerned with energy but, unfortunately, some current planning documents still measure the energy requirements of alternative water and wastewater management plans in terms of the dollars needed to purchase energy. Decisions based only on such dollar costs will be quickly outdated by rising energy prices. Decision-making today needs to take into consideration the energy units as well as dollars - and not just direct energy consumption but the total energy impact on society.

The material to be reported today is an expansion of portions of a Preliminary Report recently issued by the University of California Water Resources Center entitled "Energy Requirements of Alternatives in Water Supply, Use and Conservation". Studies summarized in this preliminary report relating to wastewater treatment and re-use have been expanded in a more recent report made to the California and Nevada Chapters of the Water Pollution Control Association last April. The policy issues and programmatic implications of energy considerations have been partially identified in two Workshops held last March and April. A third Workshop to discuss policy issues will be held September 29 and 30.

The Preliminary Report on Energy Requirements and our later studies are intended to help provide planners and decision-makers with information on the energy requirements for water supply and use, including water pollution control and wastewater re-use, so that actual energy requirements can be considered separately from dollar costs and other factors such as environmental impacts.

ENERGY REQUIREMENTS FOR WATER SUPPLY

In our Preliminary Report, we have calculated the energy requirements for supplying water to the major water service areas in California from a number of alternative systems including groundwater pumping, delivery of surface water at various points from the facilities of the Central Valley Project and State Water Project, desalting of seawater, desalting of brackish water, and reclamation and reuse of wastewater.

Table 1 traces water flows and energy requirements, in KWH/AF, for the part of the Central Valley Project that delivers water to the San Joaquin Valley. Only direct pumping power requirements are included since we estimated the energy for construction of the facilities to be only 1.5% of the total energy requirements, with maintenance energy in the same range. This table points out that one should avoid making a quick conclusion that water is energy free just because no pumping is required. Although water is delivered by gravity flow through the Friant-Kern Canal, giving a direct energy requirement of zero, pumping is required to supply water from the Sacramento-San Joaquin River Delta to the intake of the Delta-Mendota Canal and then from the Mendota Pool to land along the lower San Joaquin River which was formerly irrigated with the San Joaquin River water now diverted through the Friant-Kern Canal. The indirect energy requirement for the Friant-Kern Canal is therefore 261 KWH/AF.

Table 2 traces projected Year 2020 water flows through the delivery facilities of the State Water Project. Only 317 KWH/AF will be required for water delivery from the first reach of the California Aqueduct in the Northern San Joaquin Valley, but a tremendous amount of energy will be required for pumping over the Tehachapis, bringing the average energy requirements to 4,649 KWH/AF downstream from Pearblossom Pumping Plant. Some power will be recovered on the other side of the mountains, so that the energy required for water delivery from the end of the Santa Ana Branch will average 3,292 KWH/AF and from the end of the West Branch it will average 2,767 KWH/AF.

Table 3 summarizes the energy required to provide water by various means to the Southern Coastal area of California at the indicated elevations. Only direct pumping power requirements are listed for groundwater and the surface water diversion projects because preliminary calculations indicate that the energy for construction and maintenance of typical systems equals only about 2-4% of direct energy requirements and can therefore be ignored in a preliminary comparison of alternatives.

The Los Angeles Aqueduct, delivering water from the Owens Valley, instead of requiring pumping, actually generates 2,400 KWH/AF. Since ground water, Owens Valley water, and Colorado River water are being fully utilized, increased water deliveries for the rest of this century will likely be provided from the State Water Project which is not yet operated at full capacity. Because of the very high energy consumption of the State Water Project, there has been great interest in seeking other sources of fresh water with lower energy requirements. However, Table 3 indicates that no alternatives have yet been proven capabile of delivering large volume [1/] additional supplies of equal-quality water at a lower energy cost than the State Project.

Desalting of sea water by conventional multistage flash distillation

---

[1/] Several hundred thousand acre-feet per year processes is not practical at present because of extremely high direct energy requirements (21,200 KWH/AF in a single-purpose plant, 16,900 KWH/AF in a dual-purpose power-desalting plant). Indirect energy requirements for construction, maintenance, and chemical supply for distillation plants tend to equal about 5% of total energy requirements.

Commercial designs of reverse osmosis plants for seawater desalting have become available very recently. Direct energy requirements equal about one-half the direct energy requirements of commercial single-purpose distillation plants. Improvements expected in the near future may reduce direct energy requirements by one-half again. However, reverse osmosis seawater desalting will still require more energy than State Water Project delivery from either a direct energy or total energy standpoint. (Indirect energy requirements for construction, maintenance, membrane replacement, and chemical supply for seawater reverse osmosis plants appear to make up between 10% and 20% of total energy requirements.)

Reverse osmosis plants used for desalting of brackish groundwater tend to have indirect energy requirements equal to about 20-25% of their total energy requirements (compared to under 5% for typical surface water storage and diversion projects.) Therefore, the commercial reverse osmosis plants are not quite competitive with the State Water Project in terms of total energy requirements. Expected future improvements in reverse osmosis designs might show a slight advantage over the State Project, but for water supply to the lower elevations only. If the desalted water were pumped to an elevation of, say, 1500 feet to provide approximately the same pressure head as the State Water Project, an additional 1,200-1,300 KWH/AF would be required.

Direct municipal reuse of wastewater is not allowed and recharge of aquifers from which domestic supplies may be drawn is now being questioned because of concerns about viruses and stable organic compounds in the wastewater. Certain tertiary treatment processes (including coagulation-filtration, activated carbon adsorption, and reverse osmosis) are believed to be capable of nearly complete removal of these hazardous constituents. If direct municipal reuse were to be proven safe, however, it might not be advantageous from an energy standpoint because of the more complete and energy-consuming additional wastewater treatment needed. This comment may also apply to recharge if new regulations for groundwater recharge as proposed by the State Department of Health are adopted.

Discharge of wastewater to the ocean now generally requires secondary treatment so that level of treatment may be taken as the starting point in calculating additional energy requirements for reuse. We calculate that the total energy required for complete tertiary treatment and pumping the reclaimed wastewater to an elevation of 500 feet is about 3,000 to 3,400 KWH/AF. However, the salt concentration of the wastewater in many locations in the Southern Coastal area is 1,000 mg/l or higher. Continuous reuse of large volumes would require a desalting step to reduce the salt concentration to a more reasonable level, say 500 mg/l. Assuming that reverse osmosis treatment of the tertiary effluent reduces the TDS well below 500 mg/l and the desalted product is then blended with additional tertiary effluent to produce a blended product at 500 mg/l TDS, total energy requirements could range anywhere from 3,600 to 6,000 KWH/AF, depending on the design of equipment used.

Industrial wastewater reuse may be much more promising. The secondary treatment now required for discharge of wastewater may produce water of adequate quality for power plant cooling and other purposes with little further treatment. Only 100-200 KWH/AF may be needed to pump the wastewater from treatment plants to reuse sites. One of the most promising potential uses for wastewater is powerplant cooling. This reuse would probably require some additional treatment raising direct energy requirements to about 1,000 KWH/AF. Indirect energy requirements for construction and maintenance of the separate pipe systems needed to deliver the wastewater to sites of industrial reuse have not yet been calculated.

Agricultural reuse of wastewater is not listed in this table because, as will be discussed later, the wastewater from the greater Los Angeles area is unlikely to be used for crop irrigation on a significant scale.

A number of futuristic proposals have been advanced for water supply to Southern California. The total energy requirements of these proposed systems are hard to evaluate. For example, towing icebergs from the Antarctic appears to be competitive in terms of direct energy requirements, but the indirect energy requirements for research and development, construction, and maintenance are likely to be huge.

SOME WATER QUALITY CONSIDERATIONS

The discussion of the previous table briefly introduced some water quality considerations. The next two figures point out some additional problems which need to be considered in any plans for wastewater reuse.

Irrigation Reuse

For irrigation water supply, Figure 1 shows that as the salt concentration of the water increases, more water must be applied to leach excess salts from the soil. For example, if water with a TDS concentration of 500 mg/l is used in place of water at 200 mg/l, the volume applied must be about 3 percent greater. This is an additional factor which should be recognized when proposing to use municipal wastewater as an alternative to fresh water because one cycle of municipal use typically adds about 300 to 350 mg/l to the salt concentration of water.

Municipal and Industrial Water Supply

Several studies have developed relationships between the average life and average maintenance cost for various household items and the quality of municipal water supplies. Appliances such as washing machines, dishwashers, and water heaters along with water pipes, sewer lines and other items may be damaged by abrasion, corrosion, and encrustation from poor quality water. Energy will be required for the repair or more frequent replacement of such damaged items. Energy will also be required for delivery of bottled water, if the regular supply is undrinkable, for the manufacture of the extra soaps and detergents used, and for the manufacture and maintenance of water softeners.

We have estimated the energy requirements associated with the use of poor quality water by using published tables and formulae to calculate the dollar cost per household for the repair or replacement of various items with water supplies of different qualities. The dollar costs were then converted to energy units by using energy per dollar factors developed at the University of Illinois and Oak Ridge National Laboratory.

In Orange County (Table 4), the annual energy requirements per household for operation, maintenance, and replacement of the listed items came to 5,655 KWH when Colorado River water (750 mg/l TDS, 350 mg/l hardness) is used and only 4,567 KWH when State Project water (200 mg/l TDS, 80 mg/l hardness) is used. The energy savings from the use of State Project water, 1,088 KWH, more than makes up for the extra 812 KWH pumping energy needed to supply an average household's yearly water requirement of 2/3 AF from the State Project instead of from the Colorado River. In contrast, for the small community of Old Cuyama in Eastern Santa Barbara County, which now uses groundwater of very poor quality, our preliminary calculations indicate that a proposed desalting of the groundwater could save enough energy from reduced damage to household items to more than make up for the nearly 6,000 KWH per household per year required for construction, maintenance, and chemical supply of the desalting plant. The same kinds of damage from the increased salt content of wastewater could affect the energy balance of industrial wastewater reuse.

More studies should be made of the economic and energy advantages of arranging sequential use and re-use of water. In those areas where high quality water is being imported or could be imported, sequential use -first by municipalities, then by agriculture, and finally for recreation and wetland areas for wild fowl are attractive.

ENERGY REQUIREMENTS FOR WASTEWATER TREATMENT

SECONDARY TREATMENT

Direct Energy Requirements

Public Law 92-500 prescribes publicly owned wastewater treatment plants to provide a minimum of secondary treatment by July 1, 1977. The activated sludge process is commonly employed to meet this requirement. Table 5 shows the direct electrical power requirements for a typical activated sludge plant, totallying about 71,000 KWH per day at the 100 MGD plant size, assuming gravity discharge of effluent.

Table 6 shows the additional electricity and fuel requirements for sludge disposal. Using the sludge treatment method with the lowest overall energy requirements (sludge digestion followed by landfill disposal of digested sludge), the electricity and fuel used in sludge treatment and disposal total the equivalent of about 56,000 KWH per day for a typical 100 MGD plant. Another 2,400 KWH/day is needed for lights and miscellaneous power but nearly 69,000 KWH/day can be recovered by utilization of digester gas, giving a net direct energy requirement of 61,462 KWH/day.

Total Energy Requirements

As shown in Table 7, the direct energy makes up only 65.9% of the total energy requirements of the activated sludge plant, however, Manufacture and transport of chlorine and other input chemicals consumes another

13.6% of the total energy. The energy used in construction of the facilities, when prorated evenly over an assumed 20 year project life, makes up 20.5% of the overall energy requirements.

TERTIARY TREATMENT

Up to this point we have considered only secondary treatment. In January, 1976, EPA published a report on the impact of Public Law 92-500 on municipal pollution control technology which indicated that about 200 municipal treatment plants in California, and a total of 8,500 in the nation, were located along water quality limited stream segments and would have to use some form of advanced treatment. The most common type of advanced treatment usually provides for removal of the nutrients phosphorus and nitrogen.

Phosphorus Removal

Table 8 compares the effectiveness of two commonly used processes for phosphorus removal by showing typical levels of pollutants remaining in wastewater after treatment. The units are lbs/day for 100 MGD treatment. For reference, the first column of figures is for secondary treatment in an activated sludge plant. Alum addition to activated sludge is capable of substantial reductions in BOD and suspended solids, as well as phosphorus, but coagulation/filtration following activated sludge is even more effective and it also removes about one-third of the nitrogen plus most of the heavy metals. The question is: Does coagulation/filtration show enough improvement in treatment effectiveness to justify its higher energy cost?

Table 9 shows that the direct energy required for coagulation/filtration is slightly more than twice as great as the direct energy required for alum addition. However, when the huge energy requirements for chemical supply and the small energy requirements for construction of additional facilities are added in, the coagulation/filtration process is shown to actually require about 11 times as much energy as alum addition.

Hittman Associates prepared a report for the Council on Environmental Quality showing the environmental impacts, efficiency, and cost of energy supply. Use of their data allows us to compare the tradeoffs between pollutant removal from wastewater by various treatment methods and pollution created at other locations to produce the energy used in treatment (Table 10). For example, coagulation/filtration is more effective than alum addition, removing an extra 8,380 lbs BOD; 7,120 lbs suspended solids; 166 lbs phosphorus; 6,720 lbs nitrogen; and 2-3,000 lbs heavy metals per day in a 100 MGD plant. The extra energy consumption of coagulation/filtration, however, adds 3,033 lbs nitrous oxides; 8,344 lbs sulfur dioxide; 2,031 lbs hydrocarbons; and 5,202 lbs carbon monoxide to the air each day along with other air and water pollutants. Assigning no weight to BOD and COD, the use of coagulation/ filtration in place of alum addition removes 16-17,000 lbs pollutants per day from the wastewater, but at the sites of energy production adds 259 lbs/day pollutants to water and about 19,000 lbs/day pollutants to air.

Nitrogen Removal

Seceral different processes may be used to reduce the concentration of nitrogen residuals in treated wastewater and Table 11 compares the effectiveness of two methods. The 21,000 lbs/day remaining in the wastewater after activated sludge treatment in a 100 MGD plant can be reduced to 1,680 lbs/day by using nitrification/denitrification in conjunction with alum addition. Other processes such as ammonia stripping, or the zeolite ion-exchange process shown in the table for use with coagulation/filtration, are even more effective for nitrogen removal.

The power requirements for nitrification and denitrification in a 100 MGD treatment plant are about 60,000 and 1,000 KWH/day, respectively (Table 12). Production and transport of the methanol used consumes about 36,000 KWH/day, and construction of the additional facilities averages out to about 17,500 KWH/day. The energy requirements for ammonia stripping are somewhat uncertain, but an EPA report gives the direct power consumption as 67,000 KWH/day in a 100 MGD plant. The zeolite ion-exchange process is estimated to directly consume about 248,000 KWH/day (Table 13). Production and transport of the sodium chloride and sodium carbonate used would consume an additional 18,000 KWH/day.

Refractory Organics

In addition to nutrient removal, some treatment plants will need to use activated carbon adsorption to remove refractory organics from wastewater. Energy requirments are listed in Table 14. Pumping the wastewater through the carbon towers will consume about 31,500 KWH/day. The fuel required for carbon regeneration is equivalent to about 23,500 KWH/day. A fraction of the carbon is destroyed during regeneration. Production and transport of makeup carbon will consume energy equivalent to more than 162,000 KWH/day.

SUMMARY COMPARISON OF SECONDARY VS. TWO LEVELS OF TERTIARY TREATMENT

Table 15 summarizes total energy requirements for a range of treatment levels. The first alternative is activated sludge secondary treatment with the sludge treatment option most favorable from an energy standpoint (landfill disposal of digested sludge, no incineration). The next column shows the treatment somethimes referred to as biological-chemical, consisting of activated sludge plus alum addition and nitrification/denitrification for nutrient removal. The total energy required for this system is 2 1/2 times that of straight activated sludge. The most effective but also most energy-intensive treatment system is full tertiary treatment consisting of activated sludge treatment followed by coagulation/filtration, lime recalcination, activated carbon adsorption and zeolite ion-exchange. The total energy required is more than 12 times the total energy needed for straight activated sludge treatment. Consideration of the tradeoffs between pollutants removed from wastewater and pollutants added to the environment by energy use points out the diminishing returns from the higher level of treatment. Compared to activated sludge treatment the biological/chemical treatment removes an additional 29,000 to 77,000 lbs/day pollutants from the wastewater while the increased energy consumption adds only about 8,000 lbs of pollutants to the environment. Upgrading from biological-chamical to full tertiary treatment, however, removes only 14,000-15,000 lbs/day more from the wastewater while the much higher energy consumption adds over 50,000 lbs/day of air and water pollutants to the environment.

SIGNIFICANCE OF ENERGY CONSUMPTION FOR WASTEWATER TREATMENT

In an attempt to put into perspective the energy requirements for wastewater treatment, the State Water Resources Control Board in a 1974 report compared the electric power used in a typical treatment plant to treat an average household's daily production of wastewater with the average residential electric power consumption (assumed to be 16.8 KWH per day per household). We have updated the comparison for Table 16 by replacing direct electric power consumption in the treatment plants with figures for total energy requirements.

Activated sludge secondary treatment requires 0.609 KWH/day per household, equal to 3.6% of residential power use. However, when digester gas is utilized at the treatment plants, the total energy consumption is reduced to 0.307 KWH/day/household. Use of biological-chemical treatment for partial nutrient removal would raise energy requirements to 0.776 KWH/day/household. The use of full tertiary treatment for nearly complete removal of nutrients and refractory organics could increase energy consumption to as much as 3.75 KWH/day/household, equal to 22.3% of residential power use.

Since according to a recent Rand report, residential electric power use is only about 8.8% of overall energy use in California, treating the sewage from every household in the state with full tertiary treatment in place of activated sludge secondary with digester gas reuse would increase the state's overall energy consumption 1.8%. It might be argued that this is an insignificant increase. However, by this line of reasoning, many other individual uses of energy are insignificant. For example, gasoline consumption totals only 4.3% of overall energy use. If the energy needed for the upgraded treatment were made available by reducing gasoline consumption, Californians might feel that the resultant 42% decrease in gasoline supplies was very significant.

LAND TREATMENT

Another treatment option that should be considered wherever adequate land is available is land treatment. Table 17 shows that land treatment of liquid effluent from activated sludge treatment could effectively replace in-plant advanced treatment processes.

If land treatment is regarded simply as a method of treatment and disposal with no planned reuse, energy requirements can be compared to the treatment and disposal methods examined earlier. Table 18 indicates that the energy required for the land treatment example is slightly greater than for the biological-chemical treatment. Of course, these figures will be affected by the many, many possible conveyance distances, conveyance heads, and application systems.

Table 19 shows the breakdown of the energy requirements in the land treatment example. Assuming only 100 feet of head for conveyance pumping, about 40,000 KWH/day will be consumed in pumping 100 MGD to the land treatment site. We have made very rough estimates of 16,500 KWH/day for construction of the necessary conveyance and storage facilities. Pumping for a sprinkler application system would require about 83,000 KWH/day and manufcature and installation of the application system might require about 21,500 KWH/day.

Although concerns about stable organic compounds and viruses may prevent direct domestic recycling of reclaimed wastewater, such wastewater can at least be used for power plant cooling and other industrial purposes, for recreational lakes, or for irrigation of agricultural crops in cases where the wastewater does not come into direct contact with food intended for direct human consumption without processing adequate to kill disease organisms. The energy balance of a particular wastewater reuse system will be determined by a number of factors including: (1) the level of treatment otherwise required for disposal of wastewater; (2) the level of treatment required prior to reuse; (3) the type of conveyance system, the distance, and the change in elevation for conveyance of wastewater to the reuse site; (4) alternative sources of fresh water which will be displaced by wastewater reuse; and (5) the difference in quality between wastewater and alternative sources of fresh water. Where secondary effluent is used for irrigation, in some cases the nutrients contained in the effluent can partially replace commercial fertilizers otherwise needed by the crops. We made a preliminary estimate that the amount of nutrients which a typical crop could utilize from one acre-foot of secondary effluent could replace commercial fertilizer which would require about 62 KWH for manufacture, transport, and application. However, in some cases the excess nutrients may be detrimental to crop growth, along with heavy metals and other constituents of secondary effluent.

For our published report we prepared some simple diagrams of possible systems for irrigation reuse of wastewater. The figures on the diagrams happen to be for direct electric power requirements only. To provide a reference point, the first diagram (Figure 2) shows land disposal only, with no planned reuse. It assumes that the crop land is at the same elevation as the treatment plant, but 5 miles away. Friction losses in the conveyance pipeline total 100 feet of head, requiring pumping energy of about 130 KWH/AF.

Sprinkler application requires an additional 221 KWH per acre-foot for pumping. If the wastewater is not given land treatment, the diagram assumes that it will require tertiary treatment prior to disposal in a river.

Figure 3 assumes that the wastewater is applied for groundwater recharge and part of the reclaimed water is pumped from the ground for irrigation, industrial, or recreational purposes. It is assumed that an alternative supply of fresh water for these purposes would require 1,000 KWH/AF for pumping.

In Figure 4 the groundwater recharge and repumping are bypassed by applying the wastewater directly to crops.

Figure 5 more closely approximates the situation for the Los Angeles area. Adequate crop land may be located at an elevation 1,000 feet higher than the treatment plant and 50 miles away, requiring conveyance pumping energy of 2,600 KWH/AF. It is assumed that alternative ocean disposal of wastewater would not require tertiary treatment. However, supply of fresh water for irrigation from the State Water Project is assumed to require 3,000 KWH/AF. The energy savings in this example are much smaller than in the previous diagram.

We have carried out additional calculations which take into account the total energy requirements for a range of systems. The systems considered are listed in Table 20 with the right-hand column showing total energy requirements in KWH/day for 100 MGD.

In Table 21 the treatment required for disposal is the same as the treatment required for reuse in each case for a zero effect on energy. The energy balance is therefore dependent on the comparative energy requirements for wastewater conveyance vs. alternative freshwater supply. Where 57,000 KWH/day is needed for wastewater conveyance, there is no energy savings compared to use of local freshwater supplies, but 881,000 KWH/day can be saved by reuse where freshwater would otherwise have to be imported from distant sources. For irrigation of land far away from the treatment plant, reuse would save energy compared to importing freshwater but would be highly unfavorable compared to use of local freshwater supplies for the irrigation.

The first example in Table 22 may approximate the energy advantages of industrial reuse in many areas along the south coast of California. Where activated sludge secondary treatment is required for disposal, industrial reuse requires only biological-chemical treatment, and the only alternative water supply is from the State Water Project, wastewater reuse may be very favorable. Unrestricted reuse requiring tertiary treatment, however, would be unfavorable wherever the wastewater could otherwise be disposed of following secondary treatment. In our earlier report we concluded that the value of wastewater reuse in the southern coastal area appeared to be limited because agricultural land adequate for large scale reuse might be located far from the treatment plants, because potential industrial demand for reclaimed water did not seem very large and because direct municipal recycling was unlikely.

A recent draft environmental impact statement prepared by EPA, Region IX and the Sanitation Districts of Los Angeles County concludes that the high degree of urbanization in Los Angeles County leaves inadequate land for land applications. The nearest feasible use areas would be the high desert areas north of the San Gabriel Mountains (a distance of 100 miles) or in the Imperial Valley (200 miles away). The enormous amounts of energy and substantial costs for pipelines and pumping make these alternatives infeasible. However, the report indicates that large scale wastewater reuse for industrial purposes and landscape irrigation is feasible and can show very large energy savings in comparison with imported water.

Where desalted seawater is the only alternative to wastewater reuse, all reuse situations are favorable from an energy standpoint. The most favorable is where tertiary treatment is required for wastewater disposal but only activated sludge is required prior to local irrigation reuse. The change in treatment level saves 1,044,000 KWH/day but 57,000 KWH/day is used for conveyance to the reuse site. An additional 6,661,000 KWH/day is saved by elimination of the desalting of 100 MGD seawater. The total energy savings are, therefore, 7,648,000 KWH/day. The least favorable situation is where only activated sludge is required for disposal but unrestricted reuse requires tertiary treatment, desalting, and about 500 feet of pumping head. The increased treatment consumes 1,504,000 KWH/day and the conveyance an additional 216,000 KWH/day. However, compared to desalted seawater, the wastewater-reuse still saves 4,941,000 KWH/day.

Concluding Comments:

Some alternatives for water pollution control and water conservation may save energy, while others being proposed would increase total energy use. Where energy use would be increased by a proposed alternative, serious attention should be directed to a very basic resource management question. Is it sound public policy to adopt an alternative which consumes excess energy (which is often a non-renewable resource) to conserve water (which is a naturally renewable resource through the operation of the hydrologic cycle)?

Some very difficult management decisions, necessary to further today's societal goals and to comply with legislation lie ahead. These decisions will require wise balancing of the many trade-offs between pollution control, water supply, and energy consumption.

Analyses of the type illustrated in this paper make it possible to include energy considerations in analyzing trade-offs. The often substantial differences in energy requirements between alternatives for water pollution control and water re-use suggest the importance of more carefully examining the energy dimensions as an increasingly important factor in planning and decision-making.

TABLE 1

TYPICAL WATER DELIVERIES AND ENERGY REQUIREMENTS FOR MAJOR SERVICE AREAS OF THE CENTRAL VALLEY PROJECT

Project Feature	Water Flow or Delivery (AF)	Energy (KWH)*	KWH/AF*	Average Energy for Water Delivery** (KWH/AF)
Tracy Pumping Plant	2,410,000	583,200,000	242	
O'Neill Pumping Plant	887,000	56,800,000	64	
San Luis Reservoir Pumping	360,000	142,200,000	395	
San Luis Reservoir Generation	360,000	[94,700,000]	[263]	
O'Neill Generation	82,000	[2,520,000]	[31]	
Water Deliveries (Delta-Mendota Canal, Mendota Pool)	1,540,000			261
Water Deliveries (O'Neill Forebay)	4,000			352
Dos Amigos Pumping Plant	801,000	111,300,000	139	
Water Deliveries (San Luis Canal)	801,000			491
Friant-Kern and Madera Canals	887,000	0	0	0 (indirectly 261)

*Brackets indicate power recovery

**Does not include energy generated en route to the Delta: 609 KWH/AF by averaging Shasta, Trinity, American, and San Joaquin River releases.

TABLE 2

PROJECTED YEAR 2020 WATER DELIVERY AND ENERGY REQUIREMENTS FOR THE STATE WATER PROJECT

Project Feature	Water Delivery* (AF)	Energy (KWH)	KWH/AF	Average Energy for Water Delivery** (KWH/AF)
California Aqueduct - Delta to Dos Amigos Pumping Plant				
Delta Pumping Plant	4,211,200	1,335,700,000	317	
South Bay Aqueduct	188,400	168,800,000	896	
Water Deliveries	188,400			1203
Water Deliveries	5,700			317
San Luis Reservoir Pumping		305,500,000	408	
San Luis Reservoir Generation	655,600	[171,900,000]	[262]	
Dos Amigos Pumping Plant	3,971,800	564,600,000	142	

*After subtracting losses

**Does not include energy generated en route to Delta: approximately 665 KWH/AF from Oroville project

TABLE 2

PROJECT YEAR 2020 WATER DELIVERY AND ENERGY REQUIREMENTS FOR THE STATE WATER PROJECT

Project Feature	Water Delivery (AF)	Energy (KWH)	KWH/AF	Average Energy for Water Delivery (KWH/AF)
California Aqueduct - Dos Amigos to Junction, West Branch				
Dos Amigos Pumping Plant	3,971,800	--		
Water Deliveries	176,800			483
Coastal Branch				
Water Deliveries	762,900			483
Buena Vista Pumping Plant	2,809,300	734,500,000	261	
Water Deliveries	130,700			744
Wheeler Ridge Pumping Plant	2,644,700	774,000,000	293	
Water Deliveries	70,000			1037
Wind Gap Pumping Plant	2,589,700	1,733,500,000	669	
Water Deliveries	86,100			1706
A.D.Edmonston Pumping Plant	2,519,500	5,844,800,000	2320	
Water Deliveries	5,000			4026
Junction, West Branch				

TABLE 2

PROJECTED YEAR 2020 WATER DELIVERY AND ENERGY REQUIREMENTS FOR THE STATE WATER PROJECT

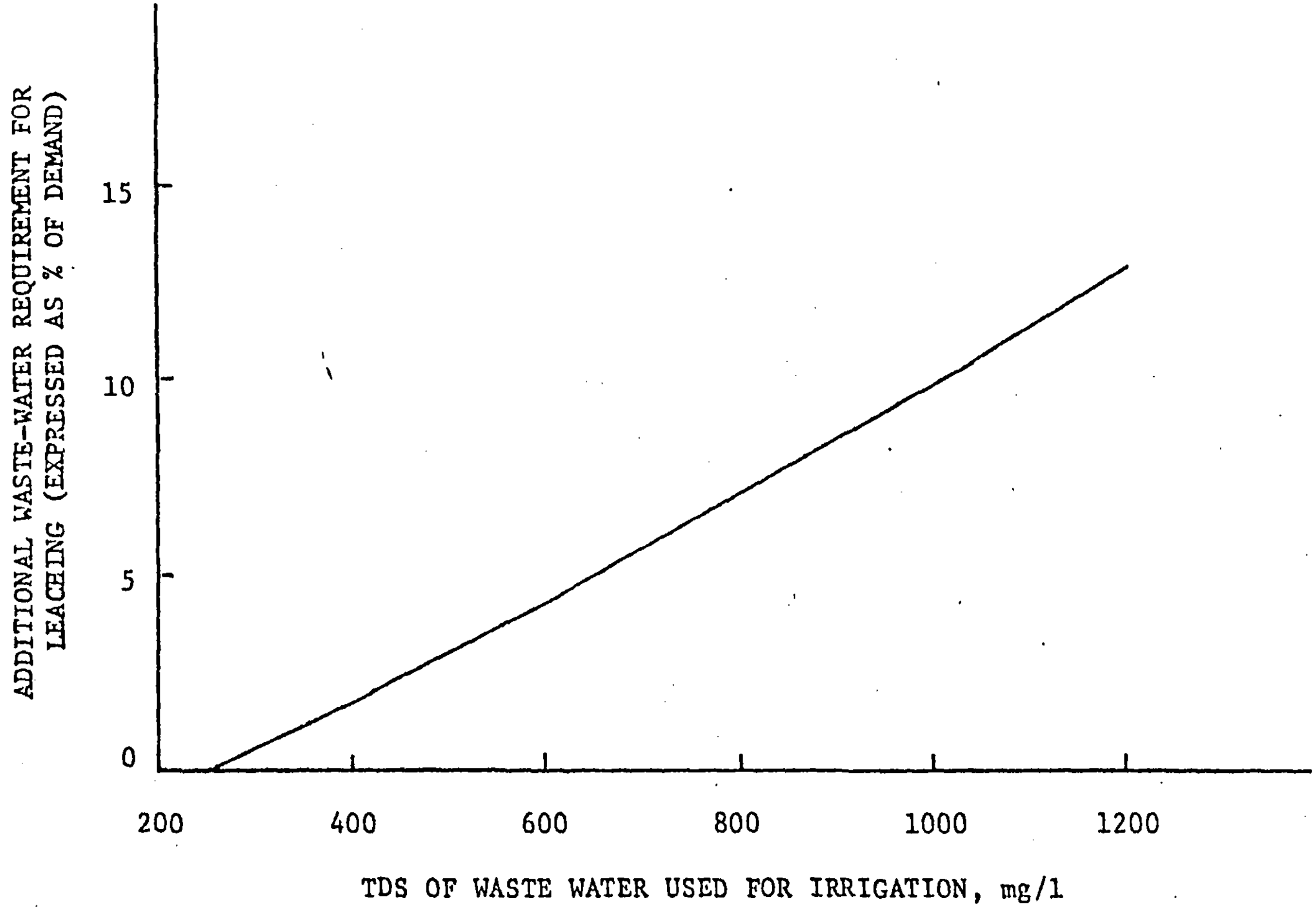
Project Feature	Water Delivery (AF)	Energy*** (KWH)	KWH/AF***	Average Energy for Water Delivery (KWH/AF)
California Aqueduct - Junction, West Branch to the End				
Junction, West Branch				
West Branch				
Oso Pumping Plant	1,637,200	433,000,000	264	
Pyramid Power Plant	1,628,200	[993,200,000]	[623]	
Castaic Power Plant	1,628,200	[1,465,700,000]	[900]	
Water Deliveries	1,628,200			2767
Santa Ana Division				
Cottonwood Power Plant	885,300	[106,200,000]	[120]	
Water Deliveries	158,000			3906
Pearblossom Pumping Plant	727,300	540,400,000	743	
Water Deliveries	117,800			4649
Devil Canyon Power Plant	604,500	[820,400,000]	[1357]	
Water Deliveries	604,500			3292

***Brackets indicate power recovery

TABLE 3

ENERGY REQUIREMENTS FOR SOME POSSIBLE WATER-SUPPLY ALTERNATIVES FOR SOUTHERN COASTAL AREA OF CALIFORNIA

System	Elevation or pressure head of delivered water (ft above sea level)	Approximate salt concentration of delivered water (mg/l)	Average direct energy req. (KWH/AF)	Approximate total energy req. (KWH/AF)
Groundwater pumping (example: energy requirement for Orange County = 130-160 KWH/AF/100 ft lift)			441	
Los Angeles Aqueducts	1,460-1,820	very low	[2,400]	
Colorado River Aqueduct	1,500	750	2,075	
State Water Project (yr 2020)	1,390-1,930	250	2,767-3,292	
Desalting of sea water				
Multistage flash distillation	500	50	21,200	23,000
Dual-purpose power-desalting	500	50	16,900	18,000
Experimental foam-enhanced vertical-tube evaporation plant	500	50	13,600	
Freezing processes	500		10,600-20,600	
Reverse Osmosis				
Commercial plants	500	350	11,000	13,000
Expected future improvements	500	350	4,500	5,300
Desalting of brackish ground water				
Reverse Osmosis				
Commercial plants	500	500	3,200	3,900
Expected future improvements	500	500	2,400	2,900
Direct municipal wastewater reuse				
After tertiary treatment	500	1,000 and up	2,000-2,400	3,000-3,400
After tertiary treatment and reverse osmosis	500	500	2,200-3,800	3,600-6,000
Industrial wastewater reuse				
After secondary treatment	200	1,000 and up	200-1,000	?
Towing of icebergs from Antarctic	500		1,500	?



Assumptions: 1) Water supply TDS of 250 mg/l used as base condition

2) Soil conductivity maintained at 12,000 micromhos

FIGURE 1. WASTE-WATER ALTERNATIVE, ADDITIONAL LEACHING REQUIREMENT VS. TDS (Source of information is USBR)

TABLE 4

AVERAGE ENERGY REQUIREMENTS PER HOUSEHOLD IN ORANGE COUNTY, CALIFORNIA, FOR OPERATION, MAINTENANCE, AND REPLACEMENT OF ITEMS AFFECTED BY WATER QUALITY

	Colorado River Water		State Project Water	
Affected item	Annual cost($)	Annual energy KWH	Annual cost($)	Annual energy KWH
Bottled water	23.76	126	9.36	50
Cooking utensils	2.07	13	1.99	13
Faucets	28.40	107	16.97	80
Garbage grinders	14.55	54	10.84	39
Sewage facilities	6.75	64	6.44	60
Cleaning products	95.40	538	45.00	259
Toilet facilities	5.38	24	3.43	15
Washable fabrics	239.87	1,158	236.12	1,140
Washing appliances	62.62	239	44.50	172
Waste-water piping	13.97	83	10.92	64
Water heater	39.28	2,588	29.96	2,318
Water piping	62.83	218	45.08	157
Water softener	40.92	217	0	0
Water-supply system	19.67	226	17.82	200
Total	655.58	5,655	478.43	4,567

TABLE 5

ELECTRIC POWER REQUIRED FOR 100 MGD ACTIVATED SLUDGE

PLANT : LIQUID TREATMENT

	KWH/day
Preliminary treatment (bar screens, comminutors, grit removal)	249
Influent pumping (30 ft. head)	12,933
Primary sedimentation	734
Activated sludge process	57,065
Chlorination	266
Effluent disposal (assume gravity flow)	0
TOTAL	71,247

TABLE 6

DIRECT ENERGY REQUIRED FOR OPERATION OF 100 MGD ACTIVATED SLUDGE PLANT

	KWH/day
Liquid treatment	71,247
Sludge treatment	56,458
Lights and miscellaneous power	2,400
Energy recovered from digester gas	-68,643
Net direct energy required	61,462

TABLE 7

TOTAL ENERGY REQUIRED FOR OPERATION OF 100 MGD ACTIVATED SLUDGE PLANT

	KWH/day	% of total
Net direct energy required	61,462	65.9
Manufacture and transport of chemicals (chlorine and polymer)	12,658	13.6
Construction of facilities	19,162	20.5
TOTAL	93,282	100.0

TABLE 8

RESIDUALS IN LIQUID EFFLUENT FROM 100 MGD TREATMENT PLANTS

Residuals (lb/day)	Treatment Level		
	Activated sludge	Activated sludge + alum addition	Activated sludge + coagulation/filtration
BOD	8,000 - 30,000	10,900	2,520
Suspended solids	8,000 - 30,000	7,370	250
P	8,400	250	84
N	21,000	21,000	14,280
Heavy metals	250 - 5,000	2000 - 3000	negligible

TABLE 9

ALUM ADDITION VS. COAGULATION/FILTRATION: TOTAL ENERGY REQUIRED FOR 100 MGD

	KWH/day
Alum addition	
Direct energy use	19,494
Alum production and transport	11,988
Construction of facilities	1,983
TOTAL	33,465
Coagulation/filtration	
Direct energy use	43,643
Lime production and transport	48,930
Carbon dioxide production and transport	277,720
Construction of facilities	6,761
TOTAL	377,054

TABLE 10

COAGULATION/FILTRATION VS. ALUM ADDITION : ENVIRONMENTAL RESIDUALS REMOVED FROM WASTEWATER VS. ENVIRONMENTAL RESIDUALS OF ENERGY PRODUCTION (100 MGD)

Residual remaining after wastewater treatment (lb/day)	Alum addition	Coagulation/filtration	Difference
BOD	10,900	2,520	8,380
Suspended solids	7,370	250	7,120
P	250	84	166
N	21,000	14,280	6,720
Heavy metals	2,000 - 3,000	negligible	2,000-3,000
Residuals of energy production (lb/day)			
Water pollutants			
BOD	6	63	57
COD	16	185	169
Suspended solids	19	210	191
N	1	14	13
Organics	5	60	55
Air pollutants			
Particulates	30	338	308
NO_x	295	3,328	3,033
SO_x	813	9,157	8,344
Hydrocarbons	198	2,229	2,031
Carbon monoxide	507	5,709	5,202
Aldehydes	7	73	66

TABLE 11

N RESIDUALS IN LIQUID EFFLUENT FROM 100 MGD TREATMENT PLANTS

Treatment level	N residuals (lb/day)
Activated sludge	21,000
Nitrification/denitrification (following activated sludge with alum addition)	1,680
Zeolite ion exchange (following activated sludge and coagulation/filtration)	420 - 840

TABLE 12

ENERGY REQUIRED FOR NITRIFICATION/DENITRIFICATION IN 100 MGD PLANT (FOLLOWING ACTIVATED SLUDGE WITH ALUM ADDITION)

	KWH/day
Nitrification	60,259
Denitrification	1,020
Production and transport of methanol	35,826
Construction of facilities	17,538
TOTAL	114,643

TABLE 13

ENERGY REQUIRED FOR ZEOLITE ION EXCHANGE AMMONIA REMOVAL IN 100 MGD PLANT (FOLLOWING ACTIVATED SLUDGE AND COAGULATION/FILTRATION)

	KWH/day
Zeolite process	247,884
Chemical production and transport	18,084

TABLE 14

ENERGY REQUIRED FOR ACTIVATED CARBON ADSORPTION IN 100 MGD PLANT (FOLLOWING ACTIVATED SLUDGE TREATMENT AND COAGULATION/ FILTRATION)

	KWH/ day
Activated carbon adsorption	31,548
Carbon regeneration	23,441
Production and transport of makeup carbon	162,480

TABLE 15

TOTAL ENERGY REQUIRED FOR THREE DIFFERENT LEVELS OF WASTEWATER TREATMENT (100 MGD)

	KWH/day		
	Activated sludge, sludge digestion, landfill disposal	Activated sludge, alum addition, nitrification/denitrification	Activated sludge, coagulation/filtration, lime recalcination, activated carbon adsorption, zeolite ion exchange
Direct energy required	61,462	137,749	616,721
Chemical supply	12,658	58,959	480,702
Construction of facilities	19,162	38,684	39,155
TOTAL	93,282	235,392	1,136,578

TABLE 16

ENERGY REQUIREMENTS FOR WASTEWATER TREATMENT COMPARED TO RESIDENTIAL POWER USE

Level of treatment	KWH/day/household[1/]	% of residential power use[2/]
Activated sludge (without digester gas use)	.609	3.6
(with digester gas use)	.307	1.8
Biological-chemical	.776	4.6
Tertiary	3.75	22.3

[1/] Assuming 330 gallons wastewater/day/household

[2/] Assuming residential power use of 16.8 KWH/day/household

TABLE 17

RESIDUALS IN LIQUID EFFLUENT FROM 100 MGD TREATMENT PLANTS

	Treatment Level			
Residuals (lb/day)	Activated sludge	Alum addition+ nitr./denitr.	Coag./filt.+ zeolite	Land treatment
BOD	8,000-30,000	6,700	840	170 - 500
Suspended solids	8,000-30,000	5,930	250	580 - 1,670
P	8,400	250	840	83
N	21,000	1,680	420-840	3,200
Heavy metals	250-5,000	2,000-3,000	negligible	20-320

TABLE 18

TOTAL ENERGY REQUIRED FOR 100 MGD WASTEWATER TREATMENT

	KWH/day
Activated sludge	93,000
Biological-chemicals: activated sludge with alum addition, nitrification/ denitrification	235,000
Tertiary: activated sludge, coagulation/ filtration, activated carbon adsorption, zeolite ion exchange	1,137,000
Activated sludge followed by land treatment	254,000

TABLE 19

ENERGY REQUIRED FOR LAND APPLICATION OF 100 MGD WASTEWATER

	KWH/day
Conveyance pumping (assume 100 ft. head)	40,000
Construction of conveyance and storage system	16,500
Pumping for sprinkler application	83,000
Construction of solid set sprinkler system	21,500
TOTAL	161,000

1 Acre-Foot Waste Water
(After primary + secondary treatment)

Pipe Transport to Disposal Site
(Assume no change in elevation, distance is 5 miles, friction losses = 20 ft. head/mile, pump requires 1.30 KWH/AF/ft.)

ENERGY REQUIRED = 130 KWH

↓

Sprinkler Application
(Assume pressure is 60 psi, equal to 138 ft. lift, pump requires 1.60 KWH/AF/ft.)

ENERGY REQUIRED = 221 KWH

TOTAL ENERGY REQUIRED = 351 KWH

Tertiary Treatment

ENERGY REQUIRED = 1,475 KWH

↓

River Disposal

TOTAL ENERGY REQUIRED = 1,475 KWH

ENERGY SAVINGS FROM LAND DISPOSAL = 1,475 - 351 = 1,124 KWH

FIGURE 2. POSSIBLE ENERGY SAVINGS FROM LAND DISPOSAL OF MUNICIPAL WASTE WATER.

1 Acre-Foot Waste Water
(After primary + secondary treatment)

Pipe Transport to Treatment Site
(Assume no change in elevation, distance is 5 miles, friction losses = 20 ft. head/mile, pump requires 1.30 KWH/AF/ft.)

ENERGY REQUIRED = 130 KWH

Sprinkler Application
(Assume pressure is 60 psi, equal to 138 ft. lift, pump requires 1.60 KWH/AF/ft.)

ENERGY REQUIRED = 221 KWH

Infiltration

Recovery of Renovated Water by Ground Water Pumping
(Assume 90% recovery of applied water, well depth is 100 ft., pump requires 1.60 KWH/AF/ft.)

ENERGY REQUIRED = 144 KWH

Reuse of 0.9 Acre-Foot

Tertiary treatment

ENERGY REQUIRED = 1,475 KWH

River Disposal

Alternative Supply of 0.9 Acre-Foot Fresh Water
(Assume delivery requires 1000 KWH/AF)

ENERGY REQUIRED = 900 KWH

Irrigation, Industrial, or Recreational Uses

TOTAL ENERGY REQUIRED = 495 KWH

TOTAL ENERGY REQUIRED = 2,375 KWH

ENERGY SAVINGS FROM LAND APPLICATION, RECOVERY, AND REUSE = 2,375 - 495 = 1,880 KWH

FIGURE 3. POSSIBLE ENERGY SAVINGS FROM LAND APPLICATION, RECOVERY, AND REUSE OF WASTE WATER.

1 Acre-Foot Waste Water
(After primary + secondary treatment)

Pipe Transport to Crop Land
(Assume no change in elevation, distance is 5 miles, friction losses = 20 ft. head/mile, pump requires 1.30 KWH/AF/ft.)

ENERGY REQUIRED = 130 KWH

↓

Sprinkler Irrigation
(Assume pressure is 60 psi, equal to 138 ft. lift, pump requires 1.60 KWH/AF/ft., also assume waste water has TDS concentration of 500 mg/l, contains nutrients needed by crop)

ENERGY REQUIRED = 221 KWH

→ **Crop Land**

Tertiary Treatment

ENERGY REQUIRED = 1,475 KWH

↓

River Disposal

Alternative Supply of Irrigation Water
(Assume 0.971 AF required if TDS concentration is 200 mg/l, assume supply requires 1000 KWH/AF)

ENERGY REQUIRED = 971 KWH

↓

Sprinkler Application of 0.971 AF → Crop Land
(Assume pressure is 60 psi, equal to 138 ft. head, pump requires 1.60 KWH/AF/ft.

ENERGY REQUIRED = 214 KWH

Alternative Supply of Fertilizer Nutrients Equal to Those Supplied by Waste Water → Crop Land

ENERGY REQUIRED = 62 KWH

TOTAL ENERGY REQUIRED = 351 KWH

TOTAL ENERGY REQUIRED = 2,722KWH

ENERGY SAVINGS FROM IRRIGATION REUSE = 2,722 - 351 = 2,371 KWH

FIGURE 4. POSSIBLE ENERGY SAVINGS FROM IRRIGATION REUSE OF WASTE WATER.

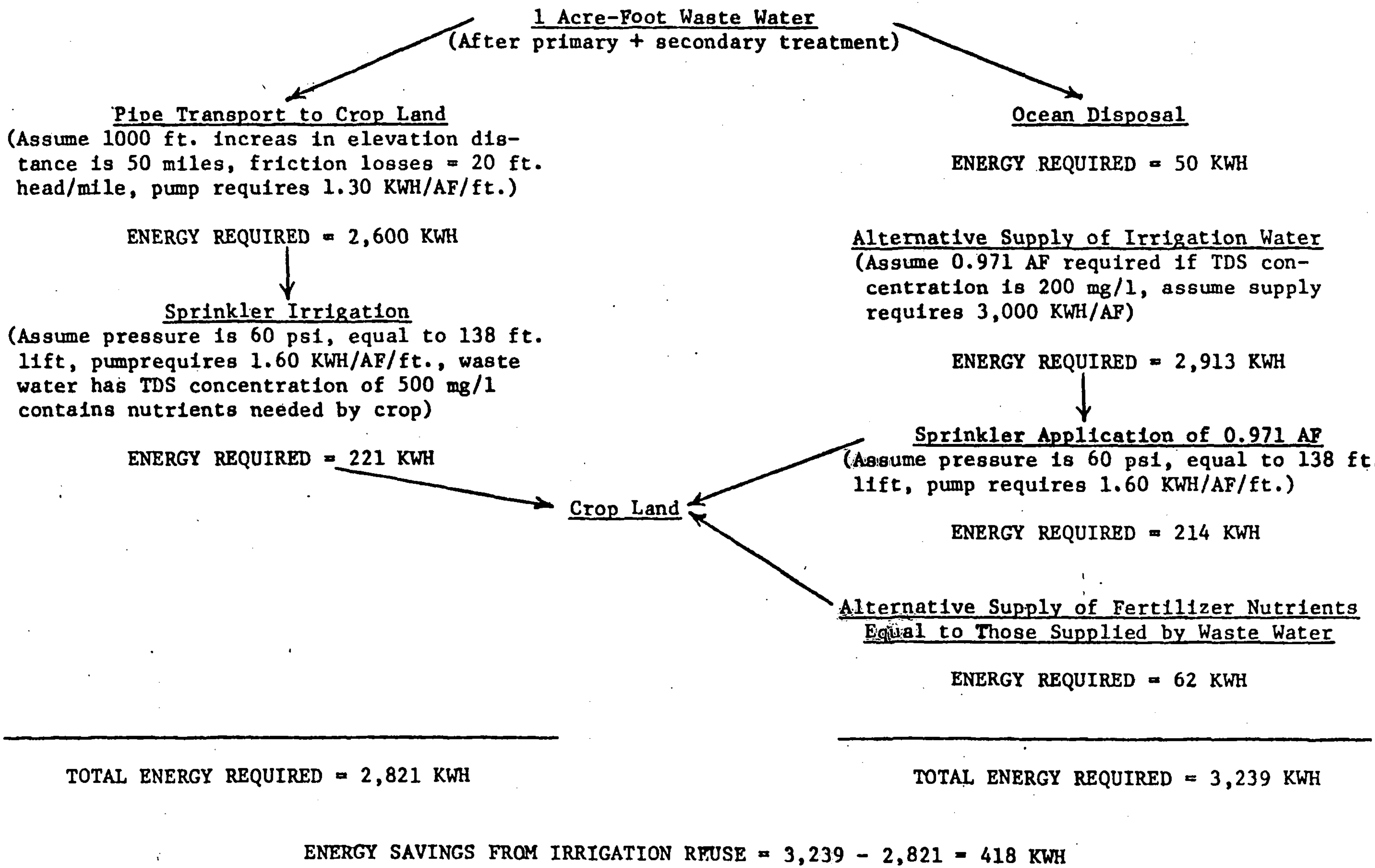


FIGURE 5. POSSIBLE ENERGY SAVINGS FROM IRRIGATION REUSE OF WASTE WATER.

TABLE 20

EXAMPLES OF SYSTEMS TO BE CONSIDERED IN EVALUATING ENERGY IMPLICATIONS OF WASTEWATER REUSE

	Total energy required for 100 MGD KWH/day
Treatment required for disposal	
1. Activated sludge (with chlorination, sludge digestion and landfill disposal)	93,000
2. Biological-chemical (activated sludge with alum addition, nitrification/denitrification, sludge digestion and landfill disposal)	235,000
3. Tertiary (activated sludge, coagulation/filtration, carbon adsorption, zeolite ion-exchange, recalcination)	1,137,000
Type of reuse	
1. Local irrigation (assume 100 ft. head for conveyance)	57,000
2. Distant irrigation (assume 1,500 ft. head for conveyance)	615,000
3. Industrial (assume 100 ft. head)	57,000
4. Unrestricted (assume 500 ft. head)	216,000

TABLE 20 (continued)

Treatment required prior to reuse		
For irrigation reuse:	activated sludge	93,000
	biological-chemical	235,000
For industrial reuse:	biological-chemical	235,000
	biological-chemical & desalting	695,000
	tertiary	1,137,000
	tertiary & desalting	1,597,000
For unrestricted reuse:	tertiary	1,137,000
	tertiary & desalting	1,597,000
Alternative sources of fresh water		
1. Local supplies		57,000
2. Imported		938,000
3. Desalted seawater		6,661,000

TABLE 21

ENERGY INCREASE OR SAVINGS FROM WASTEWATER REUSE (1,000 KWH/DAY) FOR 100 MGD PLANT

Treatment required for disposal	Type of reuse	Treatment required prior to reuse	Energy increase (+) or savings(-) from change in treatment level	Energy for conveyance to reuse site	Alternate source of water	Energy required for alternate source	Net increas or savings from reu
activated sludge	local irrigation	activated sludge	0	+ 57	imported	-938	-881
"	"	"	"	"	local	- 57	+0
biol-chem	industrial	biol-chem	"	"	imported	-938	-881
"	"	"	"	"	local	- 57	0
tertiary	"	tertiary	"	"	imported	-938	-881
"	"	"	"	"	local	- 57	0
activated sludge	distant irrigation	activated sludge	"	+ 615	imported	-938	-323
"	"	"	"	+ 615	local	- 57	+558

TABLE 22

ENERGY INCREASE OR SAVINGS FROM WASTEWATER REUSE (1,000 KWH/DAY) FOR 100 MGD PLANT

Treatment required for disposal	Type of reuse	Treatment required prior to reuse	Energy increase (+) or savings(-) from change in treatment level	Energy for conveyance to reuse site	Alternate source of water	Energy required for alternate source	Net increa or saving from re
activated sludge	industrial	biol-chem	+142	+ 57	imported	-938	-739
"	"	"	"	"	local	- 57	+142
"	unrestricted	tertiary	+1,044	+216	imported	-938	+322
"	"	"	"	"	local	- 57	+1,203
"	"	tert. & desalt.	+1,504	"	imported	-938	+782
"	"	"	"	"	local	- 57	+1,663

TABLE 23

ENERGY INCREASE OR SAVINGS FROM WASTEWATER REUSE (1,000 KWH/DAY) FOR 100 MGD PLANT

Treatment required for disposal	Type of reuse	Treatment required prior to reuse	Energy increase (+) or savings(-) from change in treatment level	Energy for conveyance to reuse site	Alternate source of water	Energy required for alternate source	Net increase(+) or savings (-) from reuse
tertiary	local irrigation	activated sludge	-1,044	+ 57	desalting	-6,661	-7,648
activated sludge	un-restricted	tertiary & desalt,	+1,504	+216	desalting	-6,661	-4,941

METHODOLOGY FOR DEVELOPING AN ADEQUATE DRINKING WATER STANDARD WHICH IS INDEPENDENT OF SOURCE

By

Carol H. Tate - James M. Montgomery
Consulting Engineers, Inc.

and

R. Rhodes Trussell - James M. Montgomery
Consulting Engineers, Inc.

Presented at the Third Annual Conference, WATERCARE, "Conservation Through Reclamation", June 10-11, 1976, Pepperdine University, Malibu Campus.

METHODOLOGY FOR DEVELOPING AN ADEQUATE DRINKING WATER STANDARD WHICH IS INDEPENDENT OF SOURCE

CAROL H. TATE
R. RHODES TRUSSELL

INTRODUCTION

This paper primarily concerns itself with standards for domestic water supplies and although the information developed herein is intended to elucidate the means by which source-independent standards are set, most of the discussion can also apply to standards of other types as well. Topics of discussion include types of water quality parameters, approaches to analysis of water supplies, approaches to water quality monitoring, and approaches to setting water quality standards.

TYPES OF WATER QUALITY PARAMETERS

Tables 1, 2, and 3 summarize water quality levels specified by five different agencies: (1) the World Health Organization, (2) the U.S. Environmental Protection Agency, (3) the American Water Works Association, (4) the U.S. Public Health Service, and (5) the State of California. The W.H.O. standards are shown because they represent an internationally recognized standard of fairly recent vintage. The U.S.E.P.A. interim primary regulations are included because they are the most recently developed and because they are of direct concern to all parties present. The California Regulations are included because they are the rules which currently apply to the audience present, and the A.W.W.A. goals (3) and U.S.P.H.S. standards are included for the purposes of general comparison. Generally the aspects of water quality about which these regulations are concerned can be divided into five categories: inorganic chemicals, organic chemicals, physical parameters, radiological parameters, and microbiological parameters. Table 1 deals with inorganic chemicals, Table 2 deals with organic chemicals, and Table 3 deals with the remaining three.

In organic chemicals of concern consist of a number of metals of established health significance, two anions of established health significance, and other miscellaneous compounds mostly associated with aesthetic effects. Most of these materials are summarized in Table 4 along with the forms they generally take in the aqueous environment and the effects with which they are generally associated. Among the more toxic compounds, arsenic, selenium, and lead are probably encountered most often. The presence of lead is generally associated with aggressive waters and lead plumbing. As lead plumbing is no longer used this problem will eventually disappear. Although the presence of arsenic and selenium are sometimes associated with man-made sources, they also occur at high levels in some natural waters and arsenic may be removed if necessary by conventional methods of treatment (8-11). Nitrate is appearing with increasing frequency in groundwater, principally due to agricultural and municipal pollution. Although work has been done attempting to develop inexpensive methods of nitrate removal (18) no completely satisfactory method is yet available.

Organic compounds mentioned in Table 2 consist of a number of the more common pesticides and herbicides and some approximate indices of the total organic and detergent content. Most of the specific compounds are shown in Table 5 along with their stoichiometric formula, their structure and their associated health effects. A great deal of research is presently being conducted in the area of organics in water supplies and indications are that some other requirements may soon be set. Among the most likely are those for aldrin, chlordane, DDT, dieldrin, heptachlor, and heptachlor epoxide as extensive environmental surveys on these compounds have recently been completed. Also likely are monitoring for chloroform and some overall measure of total organic carbon such as Non-Purgeable Total Organic Carbon (NPTOC). Other standards will undoubtedly be completed as a result of the study to be completed by the National Academy of Sciences later this year.

TABLE 1

DRINKING WATER CRITERIA - INORGANIC CHEMICALS
(all in mg/l)

Constituent	World Health Organization (1971) Recommended	World Health Organization (1971) Acceptable	World Health Organization (1971) Tolerance	EPA Interim Primary Regulation (1975) Maximum Contaminant Limit	American Water Works Association (1968) Goal	U.S.P.H.S. (1962) Recommended	U.S.P.H.S. (1962) Mandatory	California (1974) Consumer Acceptance Limits Recommended	California (1974) Consumer Acceptance Limits Upper	California (1974) Consumer Acceptance Limits Short-term	California (1974) Limiting Concentrations
Aluminum	-	-	-	-	0.05	-	-	-	-	-	-
Arsenic	-	-	0.05	0.05	-	0.01	0.05	-	-	-	0.10
Barium	-	-	1.0	1.0	-	-	1.0	-	-	-	1.0
Cadmium	-	-	0.01	0.01	-	-	0.01	-	-	-	0.01
Chromium (total)	-	-	-	0.05	-	-	-	-	-	-	0.05
Chromium (VI)	-	-	0.05	-	-	-	0.05	-	-	-	-
Chloride	200	600	-	-	-	250	-	250	500	600	-
Copper	1.0	1.5	-	-	0.2	1.0	-	-	-	1.0[b]	0.2
Cyanide	-	-	0.2	-	-	0.01	0.2	-	-	-	C
Fluoride	-	a	-	a	-	a	a	-	-	0.3[b]	-
Iron	0.3	1.0	-	-	0.05	0.3	-	-	-	-	0.05
Lead	-	-	0.05	0.05	-	-	0.05	-	-	0.05[b]	-
Manganese	0.1	0.5	-	-	0.01	0.05	-	-	-	-	0.005
Mercury	-	-	-	0.002	-	-	-	-	-	-	10
Nitrate (as N)	-	10	-	10	-	-	10	-	-	-	0.01
Selenium	-	-	0.01	0.01	-	-	0.01	-	-	-	-
Silver	-	-	-	0.05	-	-	0.05	250	500	600	-
Sulfate	200	400	-	-	-	250	-	-	-	5.0[b]	-
Zinc	5	15	-	-	1.0	5	-	500	1000	1500	-
Hardness	-	-	-	-	80-100	-	-	800	1600	2400	-
TDS	-	-	-	-	200	500	-				
Specific Conductance	-	-	-	-	-	-	-				

a. The acceptable fluoride concentration is described as a function of ambient temperature. Values range from 0.6 to 2.4 mg/l.

b. General consumer acceptance limit. Not strictly short-term.

c. Same as a. except California regulations include a lower limit, a recommended optimum, and an upper limit.

TABLE 2

DRINKING WATER CRITERIA - ORGANIC CHEMICALS

Constituent	World Health Organization (1971) Recommended	World Health Organization (1971) Acceptable	World Health Organization (1971) Tolerance	EPA Interim Primary Regulation (1975) Maximum Contaminant Limit	American Water Works Association (1968) Goal	U.S.P.H.S. (1962) Recommended	U.S.P.H.S. (1962) Mandatory	California 1974 Limiting Concentrations
Carbon-Alcohol Extract	-	-	-	-	-	-	-	-
Carbon-chloroform								3.0
extract	0.2	0.5	-	-	0.04	0.2	-	0.7
Foaming Agents				a				
(MBAS)	0.5	1.0	-	a	0.2	0.5	-	0.5
Aldrin	-	-	-	a	-	-	-	0.017
Chlordane	-	-	-	a	-	-	-	0.003
DDT	-	-	-	0.002	-	-	-	0.042
Dieldrin	-	-	-	a	-	-	-	0.017
Endrin	-	-	-	a	-	-	-	0.001
Heptachlor	-	-	-	0.004	-	-	-	0.018
Heptachlor Epoxide	-	-	-	0.1	-	-	-	0.018
Lindane	-	-	-	0.004	-	-	-	0.056
Methoxychlor	-	-	-	-	-	-	-	1.0
Organophosphates &	-	-	-	-	-	-	-	0.1
Carbamates	-	-	-	-	-	-	-	0.005
Toxaphene	-	-	-	-	-	-	-	-
2, 4-D	-	-	-	-	-	-	-	-
2, 4, 5-TP (Silvex)	-	-	-	-	-	-	-	0.1
Total Herbicide	-	-	-	-	-	-	-	-
Chloroform	-	-	-	-	-	-	-	-
Phenols	0.001	0.002	-	-	-	0.001	0.002	

a. Interim primary regulations are under preparation.
b. Regulation being seriously considered.

Many felt that the considerable attention paid to the organohalides in recent months is unjustified, and the EPA has generally taken the position that no standards should be set until their significance can be evaluated. Recent events, however, may have a significant effect on this situation. In the beginning of March 1976, the National Cancer Institute released the results of a study which showed that chloroform produces tumors in rats (20). A few days later the FDA announced that it was contemplating a ban on the use of chloroform in all of the drug-related products which presently include it (21). Among these are products such as cough syrup, toothpaste, and so on. Even more recently, the EPA recommended that water agencies begin to monitor chloroform, offered to give advice to those agencies interested in removing it, and indicated that they are studying proposals to regulate it (22). Proposed regulations for chloroform and NPTOC have also recently been discussed with EPA's advisory committees.

In the past, all of the physical parameters in Table 3 have been given recommended rather than mandatory limits and their effects have been described as being primarily aesthetic in nature. Recent events would indicate that this situation is rapidly changing. Although the direct effects of these parameters are still thought to be aesthetic, other indirect effects are now being considered to be of importance. In 1974, California (5) established a mandatory requirement for filtration to a turbidity of O.S.T.U. for all waters exposed to a significant sewage hazard. As of June 1977, the EPA interim standards will require that all surface water supplies meet a turbidity of 1 TU. These mandatory limits have been established to ensure removal of viruses and because some research has shown that particulate matter may protect pathogens from the disinfecting agent (23). Color is another physical parameter which may, in effect, be limited soon. Just as turbidity is an indirect measure of particulate material, color appears to be a crude measure of the humic substances which seem to be the primary precursors to the organohalides (24-27).

The radiation of significance in water supplies occurs in one of three forms, each of them much different where health significance is concerned. Alpha radiation results from the emmission of large, positively charged particles which are highly damaging. Each alpha particle takes the form of a helium atom stripped of its electrons and traveling at speeds as high as 10^6 m/s. Because of their mass, alpha particles cannot penetrate the epidermis, however, when ingested, an alpha source is very

TABLE 3

DRINKING WATER CRITERIA -
PHYSICAL, RADIOLOGICAL, AND MICROBIOLOGICAL PARAMETERS

Constituent		World Health Organization (1971) Recommended	Acceptable	Tolerance	EPA Interim Primary Regulations (1975) Maximum Contaminant Level	American Water Works Association (1968) Goal	U.S.P.H.S. (1962) Recommended	Mandatory	California 1974 Consumer Acceptance Limits	Limiting Concentrations
Physical										
Color	(A.C.U.)	5	50	-	-	3	15	--	15	-
Odor	(T.O.N.)	-	--	-	-	-	-	-	3	-
Suspended Solids	(mg/l)	-	-	-	-	0.1	-	-	-	-
Taste		a	-	-	-	a	a	-	-	-
Turbidity	(T.U.)	5	25	-	1[b]	0.1	5	-	-	0.5[d]
Radiological[c]										
Gross Alpha	(pc/l)	3	10	-	15	-	-	-	-	-
Gross Beta	(pc/l)	30	100	1,000	-	100	-	1,000	-	1000
Raduin 226 & 228	(pc/l)	3	-	-	5	-	-	3	-	3
Strontium 90	(pc/l)	30	-	-	-	-	-	10	-	10
Microbiological										
Coliform[c]	(org/100 ml)	1	-	-	1	None	1	-	-	1
Plankton Count	(org/ml)	-	-	-	-	None	-	-	-	-
Virus	(PFU/l)	-	1	-	-	-	-	-	-	-

a. Not objectionable.
b. Maximum contaminant level is average of 1 T.U., but may be increased to 5 T.U. under special circumstances.
c. Here the standards have been somewhat simplified to allow a straight-forward presentation. The original documents should be referred to.
d. For water exposed to significant sewage hazards.

TABLE 4 - SIGNIFICANCE OF INORGANIC PARAMETERS

Constituent	Chemical Symbol	Forms in Aqueous Environment	Effects
Arsenic	As	$HAsO_4^{=}$, $H_2AsO_4^-$, $HAsO_2$	Has been linked with skin cancer & black foot disease: recognized carcinogen
Barium	Ba	Ba^{++}, $BaSO_4^{\bullet}$, $BaCO_3^{\bullet}$	Muscle stimulant, toxic to heart, blood vessels, & nervous system
Cadmium	Cd	Cd^{++}, humic acid complex, $CdCO_3^{\bullet}$	Cause nausea & vomiting, accumulates in the liver & kidney; recognized carcinogen
Chloride	Cl	Cl^-	Imparts taste at concentrations above 400 mg/l. No known health effects
Chromium	Cr	$CrO_4^{=}$, $Cr_2O_7^{=}$, $CrO_8^{=}$, $Cr(OH)_3^{\bullet}$	Nausea, ulcers after long-term exposure; trivalent form harmless
Copper	Cu	Co^+, Co^{++}, $Co(OH)^+$, $Co(NH_3)_x^{++}$	Disagreeable taste above 1 mg/l, therefore, ingestion unlikely
Cyanide	CN	CN^-, HCN	Toxic gas released at pH's below 6; high concentrations affect nervous system
Fluoride	F	F^-	About 1.0 mg/l reduces decay in teeth, especially children; above about 4.0 mg/l causes mottled teeth; greater than 15-20 mg/l may cause fluorosis
Iron	Fe	Fe^{++}, $Fe(OH^+)$	High levels impart an unattractive appearance and taste, no health effects
Lead	Pb	Pb^{++}, $Pb(OH)^+$, $PbHA_sO_4$	Accumulates in bones, constipation, loss of appetite, anemia, abdominal pain, paralysis
Manganese	Mn	Mn^{++}, Mn^{+++}, MnO_3^-, $MnO_4^{=}$, MnO_4^-	Disagreeable taste, discolors laundry. Not considered health hazard in water because of unpleasant taste and other dietary sources
Mercury	Hg	$HgCl_2^{\bullet}$, CH_3Hg^-, $Hg(NH_3)_x^{++}$	Highly toxic to man; gingivitis, stomatitis, tremors, chest pains, coughing
Nitrate	NO_3	NO_3^-	High levels have been associated with Methemoglobenemia & diarrhea above 100 mg/l interferes with coliform test
Selenium	Se	$HSeO_3^-$, $SeO_4^{=}$	Widely believed to have symptoms similar to arsenic poisoning. Has been associated with increased dental carries
Silver	Ag	$AgCl^{\bullet}$	Fatal at very high concentrations, at low concentrations, causes a darkening of skin
Sulfate	SO_4	$SO_4^{=}$	At high concentrations, has a laxative effect on new users. No permanent effects
Total Dissolved Solids	TDS	Minerals, etc.	Very high levels have cathartic reaction and do not quench thirst
Zinc	Zn	Zn^{++}, $Zn(OH)^+$, $Zn(Cl)_x^y$	Astringent taste above 5 mg/l; higher concentrations give milky appearance & form a greasy film upon boiling; very high concentrations associated with nausea & fainting

dangerous. Beta radiation results from the emission of high energy electrons that travel very near the speed of light. Because of its smaller size a beta particle is more penetrating but less damaging than an alpha particle. Gamma radiation is electromagnetic radiation which has tremendous penetrating power but limited effect, similar to X-rays.

The standards described here set limits on the gross quantity of alpha and beta radiation and on Radium 226, Radium 228, and Strontium 90. All of the above isotopes are beta emitters and the two Radium isotopes emit alpha and gamma rays as well.

Historically, the microbiological standards are the most important standards presently being used. Present standards use the coliform organism as an indicator of sewage contamination. This method is chosen because it is not practical to assay for specific pathogens as it is too costly, the assay methods are two slow, there are too many pathogens to be evaluated, and the results are only available after the fact of disease exposure. The coliform organism is chosen as a good indicator of contamination because it is found in the human gastrointestinal tract at very high levels, because coliforms have been shown to have resistance similar to most pathogens, and because the coliform test is a sensitive, economical test. The W. H. O. standards only suggest that a water which does not show one plaque-forming unit (P. F. U.) in a liter is safe from the standpoint of viral contamination. Regular assays for virus are not recommended.

Most of the physical, radiological, and micropiological parameters described above are summarized and described in Table 6. Some of the effects are also indicated.

TABLE 5 - SIGNIFICANCE OF ORGANIC PARAMETERS

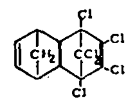
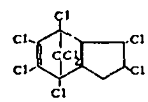
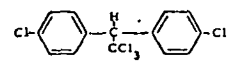
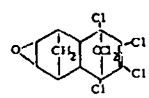
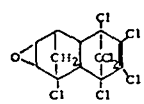
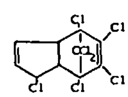
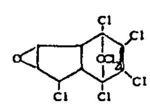
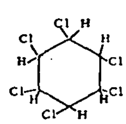
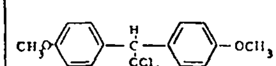
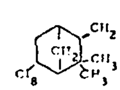
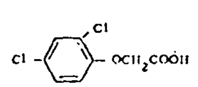
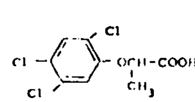
Constituent	Stoichiometric Formula	Structure	Effects
Carbon-Alcohol Extract			May produce taste and odors; provides gross indication of exposure to organics
Carbon-Chloroform Extract			May produce taste and odors provides gross indication of exposure to organics
Foaming Agent (MBAS)			Causes foaming
Aldrin	$C_{12}H_6Cl_6$		Neurotoxin; suspect carcinogen
Chlordane	$C_{10}H_6Cl_8$		Suspect carcinogen
DDT	$C_{14}H_9Cl_5$		Neurotoxin; unsteadiness, dizziness, paraesthesia, vomiting, convulsions
Dieldrin	$C_{12}H_4OCl_6$		Neurotoxin; suspect carcinogen
Endrin	$C_{12}HOCl_6$		Neurotoxin; suspect carcinogen
Heptachlor	$C_{10}H_5Cl_7$		Neurotoxin; suspect carcinogen
Heptachlor Epoxide	$C_{10}H_3OCl_7$		Neurotoxin
Lindane	$C_6H_6Cl_6$		Suspect carcinogen
Methoxychlor	$C_{16}H_{15}Cl_3O_2$		
Organophosphates		$(RO)_2P(=S)-$ OR or $(RO)_2P(=S)-S-R$	Parasympathetic stimulation, convulsions, respiratory failure, death
Carbamates		$H_2N-COOR$	Lachrymation, salivation, myosis, convulsions, death
Toxaphene	$C_{10}H_{10}Cl_8$		Neurotoxin
Herbicide; 2,4-D	$C_8H_6Cl_2O_3$		Non-poisonous; may produce unpleasant taste in water
Silvex	$C_9H_7O_3Cl_3$		Can Cause unpleasant, oily taste in exposed fish

TABLE 6

SIGNIFICANCE OF OTHER PARAMETERS

Parameters	Effects
<u>Physical Parameters</u>	
Color	Aesthetically displeasing; may dull clothes or stain food and fixtures. Colored compounds may be precursors to organohalides
Odor	Undesirable for drinking; may add odor to fish or shellfish. Some odor-causing compounds may be precursors to organohalides
Turbidity	Aesthetically displeasing; may interfere with disinfection
Specific Conductance	Related to TDS; very high levels have cathartic reaction and do not quench thirst
<u>Radiological Factors</u>	
Gross Beta	Somatic and genetic damage
Radium-226	Somatic and genetic damage
Strontium-90	Somatic and genetic damage
Gross Alpha	Somatic and genetic damage
<u>Biological Factors</u>	
Coliform Bacteria	Serves as indicator organism to determine adequacy of disinfection; generally believed to be non-pathogenic

APPROACH TO ANALYSIS

Three approaches may generally be taken to analyzing the constituents in a water. Every parameter of significance can be analyzed individually or if that is not possible, certain surrogate parameters or a general indicator might be used to evaluate the presence of a number of compounds or parameters.

Where most of the inorganic constituents are concerned, individual analysis has been used. This has proven suitable because occasional analysis of these compounds is not too costly and because there are only a certain number of inorganic compounds which are likely to appear. Monitoring some of these compounds at frequent intervals could prove very costly, however.

Turbidity is probably the best example of a surrogate parameter as it is intended as a measure of the amount of colloidal and suspended debris in the water supply. Data developed on disinfection would indicate that direct measurement of particulate matter in water supplies is the most desirable means of evaluating the significance of the particulate matter present and the degree of treatment achieved, however efficient, economical means of direct particle measurement have only recently been developed (28) and, as a result, indirect measurements such as turbidity have been used.

NPTOC is a good example of a surrogate parameter which might be used to avoid the individual analysis of an ever increasing variety of possible organic contaminants. The assumption would be that low levels of NPTOC would be indicative of low levels of all organic compounds including those of special concern.

The coliform index is, of course, the most widely recognized indicator-type parameter. This index is used to evaluate the overall safety of a water supply from a microbiological standpoint.

The principal advantage of surrogate or indicator parameter is a reduced monitoring cost. Depending on the parameter, it may also increase the sensitivity of analysis and reduce risks as is the case with the coliform index. Unfortunately, however, the principal disadvantage of this approach lies in the basic principal of substitution itself. For example, in the case of the coliform index, a number of microbiological forms have been found to be more resistant than the coliform organism, casting some doubt on the completeness of the protection that this method of monitoring affords. In the case of turbidity it can be shown that turbidity is not a reliable measure of the number of size of particulate materials in a water supply, in fact some of the most undesirable forms of particulate matter exhibit the least turbidity. NPTOC also has disadvantages as a measure of individual organic materials. To ensure that no compound is present in excessive amounts by this method alone, the NPTOC would have to be reduced below the detection limit of present-day equipment.

Once the quality parameters of importance have been singled out, the problem which remains is one of developing monitoring requirements to insure that an adequate description of the water quality is developed. The requirements ordinarily included in a monitoring program may be divided into four basic categories: requirements describing how samples should be collected, requirements describing the schedule of sampling, a description of acceptable analytical techniques, and requirements which describe the methods of statistical analysis to be used in presenting the data collected. Each of these will be briefly discussed.

Sample Collection

Probably the most important consideration in sample collection is the effort that is made to make the sample representative of the entire flow. A number of special considerations should be made regarding the techniques for storing, conditioning, and transporting individual samples are also important.

Depending on a number of factors, a flow or water body might be adequately represented by a grab sample, any number of approaches to composite sampling or by continuous monitoring. Where a flowing water is to be sampled for dissolved materials, occasional grab samples are probably adequate. Where large bodies of water are to be sampled or when suspended materials are of special interest, composite samples should be prepared. Where process control is of concern, continuous monitoring is desirable although frequent grab samples may be used if continuous monitoring is not practical.

In collecting composite samples, there are three dimensions that should be considered: time, space, and rate of flow. Quite frequently composites over time provide a satisfactory description of the quality parameter of interest. For example, when flow is very steady, a time-composited sample would provide a good assessment of suspended materials. Composites over space are important whenever the body of water to be sampled is not entirely uniform. For example, an inventory of phosphorus in a lake would best be conducted via a space-composite. Composites in proportion to flow are most important when the quality of the steam to be sampled varies throughout the day. This type of composite is most widely in characterizing wastewater flows.

Scheduling Sample Collection

The degree of frequency with which a water should be analyzed for a given quality parameter depends on the health significance of the parameter, the degree to which the concentration of the parameter varies over time, the cost of analysis, and the population at risk among other things. Depending on the method of data analysis used, the schedule of sample collection may have a very significant impact on the rigor of a water quality regulation. For example, if the average monthly concentration is limited, it may make a great deal of difference whether the sample is collected on a weekly or daily basis.

Acceptable Analytical Techniques

The most important aspect of analytical techniques for characterizing water supplies is standardization. The second most important aspect is the accuracy of the standard analytical techniques used. When good standard analytical techniques are used, data can much more easily be compared from one place or time to another, and when two parties meet to discuss their results much less time is spent establishing the value of the data being discussed. When standard analytical techniques are used, a considerable volume of data develops to characterize these techniques, their advantages and shortcomings, and their idiosyncrasies, and this leads to a much higher degree of reliability in analytical results.

Statistics of Data Analysis

There are two basic aspects of the data collected to characterize a system which common methods of statistical expression are intended to describe: the central tendency and the variability. The central tendency is usually expressed by the average, the median, the mode, the geometric mean, or similar parameters. The variability may be described by a single parameter such as the standard deviation or by a couple of parameters such as the 50 percentile and 90 percentile values. The uniformity coefficient used in specifying filter media is a good example of an expression of variability.

There are three basic approaches to describing these phenomena which are common in water supply: the arithmetic average, absolute upper or lower limits, or statistical characterization.

Arithmetic averages should be used whenever the risk due to the quality parameter of concern is proportional to the average exposure and when slight fluctuations are not too important. Viruses may be a good case in point if, indeed, ingesting one plaque forming unit results in infection. The average is an expression of central tendency, and it does not give any indication of the variability in the data. Thus, one large value can strongly bias a considerable amount of data if only the average is used. Variability is sometimes described, however, by using two averages corresponding to a number of data points. For example, if samples were collected and analyzed once a day, a monthly average and a weekly average might give a very good characterization of the data.

Absolute limits are another means of describing the levels of a water quality parameter which should be met. Limits of this sort are appropriate where a certain critical concentration exists for the parameter of concern, for example, the dissolved oxygen level in a water that is to support fish. The unfortunate aspect of limits of this sort, however, is that they do not deal with the statistical reality that there is a finite probability that every water supply will exceed every quality limit at some time or another. The promulgation of absolute limits does, however, indirectly affect both the central tendency and the variability of the product water which must be provided. Essentially, the central tendency must be significantly below the upper limit and the variability must be low enough so that the chance of exceeding the upper limit is minimized.

Possibly the most straightforward and direct way of describing the water quality which should be produced is to use a simple statistical presentation. Such a presentation might be based on either a simple arithmetic or logarithmic probability plot. The method for constructing such diagrams can be found in a number of elementary texts (14-2). Figure 1 shows a log-probability plot of coliform data for a raw water supply. Such a figure presents all the data available in a very simple, yet explicit, manner. Specifically, the figure can be used to describe the fraction of the time that the MPN exceeded any particular level. For example, Figure 1 shows that the MPN exceeded 300 about 50 percent of the time and 1,000 about 95 percent of the time. The slope of the curve is a graphic description of data variability and the position of the 50 percentile value is a good indicator of central tendency. With modern computer facilities, plots like these can be produced as easily as data can be averaged and the use of such techniques in specifying limits and presenting data should be encouraged.

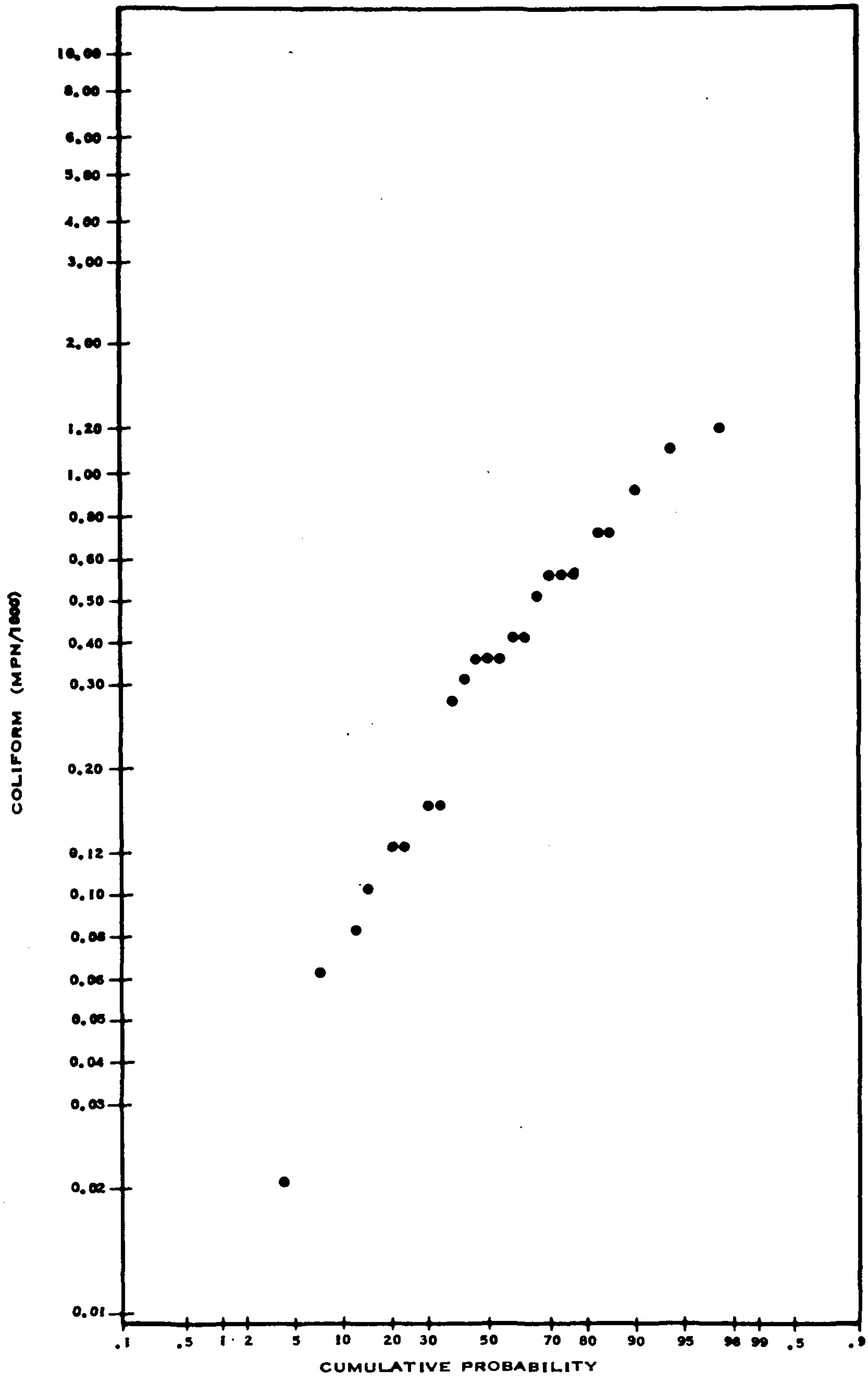


FIGURE I
LOG – NORMAL PROBABILITY PLOT OF COLIFORM DATA

APPROACHES TO SETTING WATER QUALITY STANDARDS

Basic approaches which can be used to establish water quality standards include:

(1) Specification standards
(2) Performance standards
(3) Combinations

The specification approach mandates the water or wastewater treatment process that must be used to comply with the standard. On the other hand, the determination of the optimal treatment process could be left to the water or wastewater agency by requiring a performance standard which regulates water quality. One additional option is to promulgate standards which include both specification and performance aspects.

Table 7 summarizes the three basic approaches to establishing water quality standards. It also includes further classifications of specification and performance standards which will be discussed in greater detail. For each approach, the logic for its use, as well as its advantages and disadvantages will be presented.

TABLE 7

1. SPECIFICATION OR TREATMENT STANDARDS
   - A. Process Train (no equivalent)
   - B. Process Train or Equivalent

2. PERFORMANCE OR WATER QUALITY STANDARDS
   - A. Background Levels
   - B. Detection Limits
   - C. Technological Feasibility
   - D. Health Effects

3. COMBINATIONS

SPECIFICATION OR TREATMENT STANDARDS

Specification or treatment standard may be required in lieu of water quality standards under certain situations. In the specification of treatment processes, the standards may provide only a general description of the required treatment methods, such as coagulation and filtration. Alternatively, either the standards or related guidelines may be more specific in requiring certain filtration rates, detention times, chemical dosages and other design criteria.

The establishment of treatment standards is also typically based on either the water source prior to treatment or its use following treatment. Since the quality of water from different sources can vary, methods to produce finished waters of acceptable quality may also reflect the water source. Similarly, different process trains may be specified depending on the ultimate use of the water and its associated water quality requirements.

Under certain circumstances, specification standards may be the method selected by regulatory agencies, particularly when water quality standards can not be adequately defined. For example, some organic compounds are believed to cause adverse effects, but their exact health significance is not known and detection of each individual compound is virtually impossible. In light of this situation, a regulatory agency can elect to require treatment processes (such as activated carbon), which have been demonstrated in laboratory or field tests to remove certain organics, rather than delineate limits for each organic compound in the treated water. The disadvantage with this type of approach is that it is not based on known health risks or benefits.

In practice, a specification standard is usually combined with a performance standard by defining the required process in terms of a water quality standard. Examples of such a combination occur in the California Department of Health's reclamation criteria, Title 22 of the California Administrative Code (1). For example, specification standards for reclaimed water used as a source of supply in a non-restricted recreational impoundments include adequate disinfection oxidation clarification and filtration. Definitions of adequate disinfection (coliform MPN $\leq$ 2.2 organisms per 100 ml) and filtration ($\leq$ 2 turbidity units in filtered water) add performance standards.

Process Train (No Equivalent)

One process train may be required of a water or wastewater agency before the regulatory agency permit is granted. For the defined raw water source or finished water use, no exceptions in the specification standard would be allowed.

Disadvantages:

Requiring a single process or process train with no exceptions provides no guarantee of treated water quality. A strictly uniform treatment standard does not account for local variations and may cause over-treatment, undertreatment or other water quality problems. Furthermore, the finished water quality will also be dependent upon proper operation, which requires that monitoring be done. Therefore, if a treatment standard is required, it should be supplemented by adequate monitoring for water quality parameters.

Perhaps the most serious disadvantage of the single process approach is that it restricts development of newer and hopefully better treatment techniques.

Advantage:

One advantage of a single specified treatment process train is its simplicity. Complexities and ambiguities in decision-making would be reduced. Water and wastewater agencies would be fully aware of the requirements they are required to meet.

Process Train or Equivalent

A treatment standard for a given process train or its equivalent has been used in some instances. In the demonstration of equivalency, the burden of proof is on the water or wastewater district, with the ultimate decision still resting with the regulatory agency. Proof that a proposed process is equivalent to the standard process could involve literature searches, laboratory analyses, pilot testing or full-scale testing.

Disadvantages:

The determination of equivalency can be a difficult procedure. If a treatment process is specified, the significant water quality parameters would still have to be identified and analyzed to demonstrate equivalency of treated water. Since the specification of a treatment standard is typically warranted when a given parameter causes concern but its significance is not known or its measurement is a problem, the necessity of using the same parameter to establish equivalency may be extremely difficult.

The demonstration of equivalency can also be costly, and delay provision of adequate treatment. In addition, interpretation of results may not be totally straightforward and include subjective as well as objective judgments.

Advantage:

The primary advantage of allowing tests for an equivalent process if that new developments are allowed and, in fact, encouraged. It is also possible that such new developments could produce cost savings as well as acceptable water quality.

PERFORMANCE STANDARDS

When performance standards are required, the regulations apply to the quality of treated water. Provisions for monitoring and reporting are also typically included. The selection of an optimal treatment process which will produce the given water quality objective is basically left to the water or wastewater district.

Water quality standards may be based on background levels, detection limits, technological feasibility, aesthetics, health effects or combinations thereof. Once water quality standards are clearly defined and based on known effects, it would be logical to require a single set of standards for a given use of treated water, regardless of its source.

Background Levels

The first method of establishing water quality standards is to base them on "natural" or background levels in water supplies. For example, the Public Health Service standards (4) for radioactive constituents are essentially based on "natural" levels in water supplies. Pesticides, although not "natural" compounds, are regulated by standards which are based on "background" levels that have resulted from worldwide pesticide use in the last thirty years.

The logic of setting water quality standards by background levels assumes the compounds in question are normally present in water at levels which apparently cause no adverse effects. These same compounds in "unnaturally" high concentrations are known to produce adverse effects, either acute or chronic. Therefore, the approach to setting standards limits these compounds in treated water to natural or background levels.

Disadvantages:

The use of background levels to set water quality standards assumes that the effect of all relevant parameters are understood. This is not necessarily the case, particularly for health effects. Furthermore, adverse impacts of certain compounds may not even be recognized, so measurements of background levels would not be made. Thus, insufficient knowledge precludes a thorough evaluation of background levels.

Since thousands of compounds which can ultimately end up in water supplies are being synthesized yearly, the analysis of background levels becomes increasingly more complicated. Concentrations of these chemicals are likely to be at or below limits of detection.

If compounds are detected, their significance may be unknown. Lack of long-term exposure by large populations or latent rather than immediate effects may obscure results. A distinction may be made for long-term effects of "natural" materials (such as radiation) which have been present in water supplies for millions of years, and synthetic materials (like pesticides) which have produced only recent exposure to humans. Even with naturally occuring compounds (such as organics which cause color) historical data has not included measurements and cannot be keyed to effects. If certain water quality constituents in very low levels are later found to have adverse effects, it is logical that standards should aim at treated water wherein their concentrations are lower than natural or background levels.

In addition, if all relevant parameters are thoroughly understood prior to setting background level standards, the historical support to assess effects may be lacking. For example, historical data on chloroform background levels in drinking water supplies is almost certainly not available, since chloroform was only recently suggested as presenting a possible health risk in drinking water.

Assuming data on background levels and the effects of relevant water quality parameters were available, other complexities in standards setting may follow natural or background levels of key elements or compounds will vary with time and the locations examined. For example, background levels could include California only, the United States, or the world, and would result in different standards depending on the choice of data base. Since temporal variations may also be important, a decision on standards would also have to determine whether the 50, 90 or other percentile should be included as the background level in standards. This process may also be expensive and time consuming.

Advantages

Compared to other bases for standards, the establishment of background levels is fairly straightforward and practical. Regulatory agencies can proceed directly from doing surveys, analyzing data on levels to setting standards.

Although precise information is lacking, a historical perspective suggests that background levels of various constituents in water supplies have afforded general protection to its users. Disease incidence (31) or death rates attributed to water quality have typically been much lower than those from other causes, so an adequate degree of protection in drinking water has been assumed.

Unless new studies of long-term effects from low or background of certain materials demonstrate that this assumption is incorrect, use of background levels for standards will provide some assurance of safety. To date, standards that include background levels for selected water quality components have been widely used and accepted.

DETECTION LIMITS

Setting water quality standards based on detection limits has been widely used and can be illustrated by several examples. The United States Public Health Service (4), Environmental Protection Agency (2) and the California Department of Health (5) drinking water standards for coliform organisms as indicator bacteria specify minimum limits as detected by the multiple tube fermentation or membrane filter technique.

Similarly, the Public Health Service (4) limit for chromium (0.05 mg/l) was based on the lowest amount analytically determinable when it was established in 1946 and was not changed in the 1962 revision. Other agencies or groups have proposed a virus standard, based on detection limits, such as one plaque forming unit per 100 gallons.

The logic behind setting a standard by detection limit is straightforward. A constituent found in water supplies is known to have adverse effects. It is known or assumed to have no harmless dose and thus is undesirable in any amount. Therefore, the concentration should be "none", which is practically measured as being at or below the limits of detection. As an alternative to setting a water quality standard, a treatment process known to remove the item of concern could be required.

Disadvantages

In some cases, establishing standards by detection limits would not be based on quantified effects, but rather on analytical technology.

Such a standard may also prove costly to water or wastewater districts, who would need to provide or have access to the latest analytical techniques. Additionally, laboratory analyses on the fringes of detection limits often require special modifications or precautions which increase the cost per analysis.

A final disadvantage to this type of standard is that the standard itself would be expected to change with every advance in analytical techniques. This could cause confusion plus expenses in modifying analyses or treatment processes.

Advantages

In certain cases, the use of standards based on detection limits is warranted, particularly if the alternative is doing nothing to regulate a constituent with adverse effects. It may be the only choice if a performance standard rather than a treatment standard is desired.

Standards based on detection limits can also provide positive support in relations between a water or wastewater district and its customers or the general public. If the standard is met, the district can state that the constituent has been analyzed and none was detected.

TECHNOLOGICAL FEASIBILITY

Performance standards may also be based on technological feasibility of reducing undesirable constituents by water or wastewater treatment. For example, the carbon chloroform extract (CCE) limit imposed by the

Public Health Service (4) was set at the lowest level attainable by treatment because there was a general inability to clearly define the chemical and toxicological nature of this material, which was judged to be undesirable. Turbidity limits in drinking water standards, while linked to health risks or aesthetics, have been generally established at limits which reflect technological feasibility.

The logic in establishing standards from technological feasibility begins with the determination that the constituent has adverse effects at any concentration or at least the lower concentrations are better. When a practical process exists which will reduce the constituent at a reasonable cost, the performance standard should be set at the level which the given process can achieve.

Disadvantages

For some parameters, it is difficult or impossible to measure what treated water quality is feasible. For example, virus detection in treated water may involve sample sizes larger than currently practical to assess the product of certain technologically feasible treatment schemes.

Limits set by this method are not necessarily based on effects. For example, CCE limits which meet the standards may or may not be harmful, depending on the composition and concentration of the numerous organics which comprise the fraction analyzed as CCE. Thus, technologically feasible processes may overtreat or undertreat the water. Overtreatment, while it can be accomplished, may not be necessary and could increase costs.

Advantages

Monitoring and performance data on technological feasibility are readily available from existing plants, so it is relatively easy to establish treated water quality levels and set standards.

For many water or wastewater districts, costs to meet the performance standards would be reasonable since the districts would already be using technologically feasible treatment processes. Monitoring costs for some parameters, such as turbidity, would be maintained at a reasonable level. Thus, practicality and cost could be advantages to this approach.

AESTHETICS

Setting goals or standards based on aesthetic concerns is probably the oldest method of judging water quality. From ancient times, consumers have initially judged their water by its taste, odor, color and clarity. Recent standards set by regulatory agencies include aesthetic considerations, usually as recommended rather than mandatory limits. For example, the Public Health Service drinking water standards (4) included recommended concentrations for constituents which could affect taste (TDS, chloride, sulfate, copper, iron, phenols), color (iron and manganese) and odor. Similar reasoning is included in the California Department of Health (5) drinking water regulations on consumer satisfaction and related topics. The interim EPA drinking water standards (2), which currently include only primary standards for health protection, will consider secondary standards later and could include aesthetics.

The principal goal of aesthetic standards or recommendations is to produce a treated water which pleases consumers. Such standards could also produce some associated health benefits.

Disadvantages

Aesthetic standards are not based on effects of the regulated parameters. In some cases, presence of an aesthetically pleasing water could provide a false sense of security if health-related water quality factors were not analyzed simultaneously. The classic example of this deficiency was illustrated by Sir John Snow's 1849-54 analysis of increased typhoid risks associated with the Broad Street well, a water supply preferred by consumers over other supplies because of its superior taste (5).

Advantages

Pleasing aesthetic qualities can be expected to increase public acceptance of and confidence in their treated water supply. They can also serve to discourage use of alternative sources or individual treatment uses which may be aesthetically pleasing but have less quality control on health related parameters.

HEALTH EFFECTS

Setting standards based on health effects is certainly a logical approach since it aims at controlling those parameters which can have the greatest significance in water supplies. Ideally, all water quality standards would be established on this basis. If a constituent is known to cause some adverse health effects but the concentrations in drinking water which cause these effects are not understood. Studies should be made to develop standards or to determine that they are not necessary.

Examples of standards established on a health basis are numerous. Rationale developed by the Public Health Service (4) included health related standards based on toxicological studies for cadmium, barium, arsenic, nitrate and other inorganic constituents. Recently proposed EPA standards for radiation (33) assume there is no harmless dose for ionizing radiation and base the maximum contaminat levels on cost effectiveness of health risk reductions.

TOOLS

The basic tools of establishing health-related water quality standards are epidemiology and toxicology. Work can begin with either tool, and should be confirmed with the other. A rational approach for using these tools follows.

EPIDEMIOLOGY

Epidemiology is the study of the distribution and determinants of diseases and injury in human populations. In studies of chronic diseases, either retrospective or prospective studies can be used.

Retrospective studies begin with the selection of people diagnosed as having a disease (cases) and a comparison with persons who do not have the disease (controls). Then, past records are examined to determine previous exposure of the two populations to a given factor which is suspected of increasing health risks. A careful selection of cases and controls is imperative. Populations must be matched and adjusted for age, sex and other categories. Analyses are then based on statistical methods.

Advantages of retrospective studies (relative to prospective studies) are that they are relatively inexpensive, require a smaller number of subjects, produce relatively quick results and are suitable for evaluations of rare diseases. Disadvantages include incomplete information, biased recall of subjects, problems in selecting control group and matching variables and results which produce information on relative risks only (32).

Prospective studies involve a different time progression than retrospective studies. Prospective studies start with a group of people (a cohort) all considered to be free of a given disease but who vary in exposure to a certain noxious factor. The cohort is then followed in the future to determine differences in the rate at which the disease develops in relation to the factor.

Advantages of a prospective study are that it lacks bias in the factor, yields incidence rates as well as relative risks, and can produce associations with other diseases as a by-product. Disadvantages include a possible bias in ascertainment of the disease, a requirement for a large number of subjects, a long follow-up period before results are obtained, a problem of attention among subjects, changes over time in criteria and methods and a high cost.

To date, relatively few epidemiological studies of water quality components have been conducted. Notable samples are reported studies from Holland (33) which showed that death rates from cancer were higher among those persons whose municipal system derived water from a river than among those who derived their water from wells. A more recent study (34) showed a similar result in Louisiana. The inference from the latter study was that organic compounds, specifically chlorinated organics, were related to higher cancer death rates.

Retrospective studies are almost always the choice for water quality related epidemiological studies, since time delays inherent in prospective studies would postpone adequate health protection if the future determinations indeed indicate that a factor is harmful. However, several problems are associated with retrospective studies. One is the difficulty in finding a control group which has the same water quality as the case group, but has all other veriables closely matched. Since low frequency chronic effects (carcinogenesis, mutagenesis, teratogenesis) are being investigated, the population must necessarily be large. Final results do not indicate cause and effect. Instead, they indicate only relative risk factors. Often unrelated factors may obscure data. Because of the heavy dependence on statistical methods, such studies are frequently vulnerable to criticism. A futher complication is associated with use of the risk factor. If no relative risk factor is determined, the influence of a factor cannot be automatically ruled out. For example, two populations could show identical cancer death rates, one related to asbestos and the other to chloroform in drinking water, epidemiological studies would not distinguish this information. If a positive risk factor is indeed established, then further studies, primarily based on toxicology, would be necessary to examine which compounds cause the effect.

Epidemiological studies do, however, have some advantages in establishing health-related standards. Results are based on data from humans rather than other animals and do not have problems associated with extrapolations from one species to another. Chronic effects, including relatively minor or rarely occuring effects, can be examined.

TOXICOLOGY

If a positive risk factor is determined from epidemiological tests or adverse health effects are otherwise suspected, toxicological studies should be conducted to determine effects of a water quality related factor.

Toxicological tests can be used to establish whether a compound produces immediate and usually drastic effects (acute effects) or long-term and potentially subtle effects (chronic effects). Determinations can be made of a lethal dose (dose equals the product of concentration and time) which will kill 50% of a group of test animals, referred to as LD_{50}. Similarly, with a given time period, a lethal concentration (LC_{50}) can be estimated (36). However, toxicological tests for constituents in a water supply are more likely to require testing of chronic rather than acute effects. Determination of chronic effects should examine whether a compound is carcinogenic (causes cancer), mutagenic, teratogenic (produces birth defects), or initiates changes in feeding, reproduction or other behavior.

One method of establishing a toxicological program is screening. Various fractions can be extracted from water for subsequent testing of general classes of constituents. For example, organics could be extracted or concentrated to determine whether this group is an active fraction in a water supply. Some groups (36) have recommended that complete toxicological evaluations should be made of each actual treated water supply intended for human consumption, with its real mixture of residual characteristics. Other studies could be aimed at elucidating reactions of specific compounds (within active fractions) that are routinely found in many treated water supplies. Such test results would have more widespread applicability but would not account for synergistic or antagonistic effects of that one compound in association with others found in drinking water.

In conducting these toxicological tests, consideration should be given to the entire body burden or insult which derives from certain compounds. The total exposure from water, air, food or other environmental sources should be assessed to determine whether the relative contribution from the water supply is significant. For example, the presence of chloroform in drinking water has been a subject of great concern, but that contribution to the body burden should be compared with its contribution from air, food and other sources, where it has been detected in approximately the same concentrations (38).

Because of ethical and moral considerations, toxicological tests are not currently made on humans. Therefore, testing is done on bacteria, cell lines derived from higher animals, or laboratory animals.

Screening programs have been developed which can rapidly evaluate large numbers of compounds. An example of this type of approach is the Ames test (35) which uses bacteria and mammalian cell lines to assay mutagenicity. The test uses Salmonella Typhirium as a sensitive bacterial indicator for DNA damage caused by mutagens, and mammalian liver extracts for metabolic conversion of carcinogens to their active mutagenic forms.

The detections of carcinogens by mutagenic effects is based on a 90% correlation between carcenogenicity and mutagenicity as observed in the test. Thus, it provides a practical first screening of suspected compounds. However, it has one limitation in that some carcinogenic compounds of interest in drinking water, such as carbon tetrochloride and dieldrin, do not exhibit mutagenic effects in the Ames test. Therefore, supplemental confirmation by epidemiological or other toxicological tests would be essential for items of potential concern.

After screening by some means, compounds which produce adverse effects should be tested on a series of animals, such as rodents (mice or rats) and primates (monkeys). Generally, the in vitro toxicity determined by whole animal tests will be less than measured with in vitro cell line tests. This occurs because the body acts on toxic substances by excretion and elimination, detoxication and metabolism, which cannot all be effectively duplicated in in vitro tests (37).

Difficulties arise in interpreting toxicological test results or in extrapolating them to man. Many toxicological tests are aimed at finding out a large amount of information in a short amount of time. Therefore, they rely on exposure to higher concentrations than would be present in drinking water. Also, some toxicological methods such as injection of the compound under the skin, may not accurately duplicate responses of ingestion with drinking water. Finally, the need to scale up results from mouse (or other animal) to man, leaves some questions unanswered because of differences in body weight, metabolism and others. If exact doses and effects can be determined, there are still some problems in the toxicological approach. If the tests indicate that the constituent has a threshold level below which it has no adverse effects, the question arises as to what safety factor (10, 100, 1000, etc.) should be built into a regulatory standard and whether the most sensitive people in the population should be adequately protected. If no threshold limit can be found and any amount is bad, the health related decision on standards must be based on benefits (or avoiding risks) versus costs. For example, if cancer mortality could be tied to chloroform levels, the question might be asked of consumers, what amount they would be willing to pay (dollars a month for water treatment) for a given percentage reduction in cancer risk. Ultimately, these types of decisions should be made by the social and political decision makers.

Disadvantages

Toxicological or epidemiological tests to determine health effects and the standards that are based on them are complex, costly and very time consuming. This leaves the question of what should be done in the meantime if preliminary findings point to a suspected health-risk related constituent in a water supply. In such a situation, specification standards or performance standards based on detection limits may be used.

Another disadvantage is the uncertainties and ambiguities associated with results. Epidemiological studies provide only relative risk data, not information or cause and effects, and are often open to criticism of their statistical method. Toxicological testing involves extrapolation and some subjective decisions in setting standards.

Advantages

The overwhelming advantage of health based standards is that they are related to the effect of the parameter under consideration. Since the ultimate aim of water quality standards is to provide public health protection, this method provides the most logical and scientific approach to the problem. In addition, the use of standards based on health effects can be very efficient. The technique prevents establishing unnecessary limits on water quality and prevents overtreatment in certain cases where uncertainty would otherwise exist and a conservative approach to treatment would be required. Therefore, this approach could ultimately be cost effective from the standpoint of treatment.

CONCLUSION

Of the several approaches to setting standards, the most logical appears to be establishing water quality standards based on an understanding of health effects and their causes. However, it does not appear at this time sufficient data exists to set all standards by this method. In fact, definitive information may never be available, particularly for chronic effects of compounds found in very low concentrations in water supplies.

If health effects for all parameters of concern could be developed, it would certainly be rational to suggest that a single set of water quality standards would suffice for all supplies, regardless of source. Information regarding the feasibility of this approach may be provided in the near future.

Some trends appear to be developing in the direction of a single standard. The EPA drinking water standards to take effect in 1977, which include regulations on treated water without specification of its source, exemplify this trend.

REFERENCES

1. World Health Organization, "International Standards for Drinking Water", W.H.O. Geneva, 1971.

2. Environmental Protection Agency, "National Interim Primary Drinking Water Regulations", Federal Register, December 24, 1975.

3. A.W.W.A., "Quality Goals for Potable Water", JAWWA, 60:1317 (December 1968).

4. U.S.P.H.S., " Public Health Service Drinking Water Standards-1962", PHS Pub. No. 956, U.S. Gov't Printing Office, Washington (1962).

5. California Department of Health, Laws and Regulations Relating to Domestic Water Supplies Quality and Monitoring," Title 17, California Administrative Code Part 1, Chapter 5, subchapter 1 (1974).

6. McKee, J.E., and Wolf, H.W., Water Quality Criteria, California State Water Resources Control Board, Publ. No. 3-A (1963).

7. Camp, T.R., Water and Its Impurities, Reinhold, New York (1963).

8. Shen, Y.S., "Study of Arsenic Removal From Drinking Water", AWWA, 65:543 (August 1973).

9. Shen, Y.S., and Shen, C.S., "Relation Between Black-foot Disease and the Pollution of Drinking Water by Arsenic in Taiwan", WPCF, 36:281 (February 1964).

10. Gulledge, J.H., and O'Connor, J.T., "Removal of Arsenic (V) from Water by Adsorption on Aluminum and Ferric Hydroxides", AWWA, 65:543 (Agusut 1973).

11. Ferguson, J.F. and Grovis, J., "A Review of the Arsenic Cycle in Natural Waters", Water Res, 6:1259 (1972).

12. Gardiner, J., "The Chemistry of Cadmium in Natural Water - I. A Study of Cadmium Complex formation using the Cadmium Specification electrode", Water Res, 8:23

13. Stumm, W. and Morgan, J., Aquatic Chemistry, Wiley, New York (1970).

14. Hem, J.D., and Dierum, W.H., "Solubility and Occurrence of Lead in Surface Water" AWWA, 65:562 (August 1973).

15. Butler, J.M., Ionic Equilibrium: A Mathematical Approach, Addison-Wesley, Reading, Mass. (1964) pg. 405.

16. Anon, Occupational Exposure to Mercury, U.S.H.E.W. 1973.

17. Kraybill, H. F., "Origin, Classification and Distribution of Chemical in Drinking Water with an Assessment of Their Carcinogenic Potential", Conference on Environmental Impact of Water Chlorination, Oak Ridge National Laboratory, Oak Ridge, Tennessee (1975).

18. Holzmacher, R.G., "Nitrate Removal from a Groundwater Supply", W & SW, Ref. No. R-184 (1976).

19. O'Brien, R.D., Insecticides: Action and Metabolism, Academic Press, New York(1967).

20. Anon, "Chloroform Tagged as Carcinogen in Mice", Chem. & Engr. News, p. 8, March 8, 1976.

21. Anon, "Cancer Tag to Kill Drug Use," Chem. & Engr. News.

22. Anon, "Chloroform Levels in Cities' Water", Wall Street Journal, p. 9, March 29, 1976.

23. Symons, James M. & Hoff, John C., "Rationale for Turbidity Maximum Contaminant Level", Proceedings of Third Water Quality Technology Conference, AWWA, Atlanta, December 8-10, 1975.

24. Rook, J.J., "Formation of Haloforms During Chlorination of Natural Waters", J. Wrt. Trt. Exam., 23:234 (1974).

25. Bellar, T.A., and Lichtenberg, J.J., "Determining Volatile Organics at Microgram-per-liter Levels in Water by Gas Chromatography", JAWWA, 66:1739 (December 1974).

26. Symons, J., el at, "National Crganics Reconnaissance Survey for Halogenated Organics", JAWWA, 67:634 (November 1975).

27. Rook, J.J., "Haloforms in Drinking Water", JAWWA, 68:168 (March 1976).

28. Tate, C.H. & Trussell, R.R., "Survey of Particle Removals by Water Treatment Plants", March 1976, unpublished.

29. California State Department of Health, Reclamation Criteria, (California Administrative Code, Title 22, Division 4, Chapter 4), 1975.

30. Environmental Protection Agency, "Interim Primary Drinking Water Regulations - Proposed Maximum Contaminant Levels for Radioactivity", Federal Register, August 14, 1975.

31. McDermott, J.H., "Virus Problems and Their Relation to Water Supplies", JAWWA 66:12, 693 (December 1974).

32. Hausner, J.S. and A.K. Bahn, Epidemiology, W.B. Saunders Company, Philadelphia (1974).

33. California State Water Resources Control Board, Department of Water Resources, Department of Health, "A 'State-of-the-Art' Review of Health Aspects of Wastewater Reclamation for Groundwater Recharge", Sacramento (November 1975).

34. Talbot, P. and Harris, R.H., "The Implications of Cancer-Causing Substances in Mississippi River Water", A Report by the Environmental Defense Fund, Washington, D.C. (November 1974).

35. McCann, J., E. Choi, E. Yamasaki and B. Ames, "Detection of Carcinogens as Mutagens in the Salmonella Microsome Test: Assay of 300 chemicals", Pro. Nat. Aca. Sci. USA, 72:12, 535 (December 1975).

36. World Health Organication, "Reuse of Effluents: Methods of Wastewater Treatment and Health Safeguards," Report of a WHO meeting of experts, "WHO Technical Report Series No. 17, Geneva (1973).

37. Purdom, P., Environmental Health, Academic Press, New York (1971).

38. McConnell G., D. Ferguson and C. Pearson, "Chlorinated Hydrocarbons in the Environment", Endeavour 34:1, 13 (January 1975).

METHODOLOGY FOR DEVELOPING AN ADEQUATE DRINKING WATER STANDARDS WHICH IS INDEPENDENT OF SOURCE

QUESTIONS AND ANSWERS

Question: Are mutagenic compounds likely to cause mutations to the biological creatures in our treatment processes?

Anwer: There is a screening test which is described in the paper which I didn't get to go into called the "Ames Test," where you use a salmonella bacteria or liver extract cells. You can screen all sorts of agents very quickly and tell if they are mutagenic. Approximately 90% of the compounds that they have found screened in these tests are also carcinogenic - that's the primary reason I was talking about that and notable exception to that is carbon tetrachloride which is of concern as a chlorinated organic. It's carcinogenic but not mutagenic and so it wouldn't show up in this type of test. As far as to what the mutagenes would do to the bacteria in the treatment process, they are similar to the bacteria that they use in the screening test. So I would certainly think that they would have those types of effects upon them. I'm sure there are mutations occurring all of the time, at least in the bacteria; perhaps one out of ten million are mutating. I don't imagine this mutation would upset a treatment process.

Question: Would you comment on the virus in surface waters and what basic literature research you might have done or would direct us to do to find out the ramifications of viruses? Are they significant? Are they a negligible or a serious thing if there is one in a handred gallons or one in a thousand gallons? How do they relate to a public rest-room, for instance? What's the relative exposure?

Answer: On literature research, Rhodes Trussell and I published a paper for National Water Supply Information Association. If anybody is interested in this paper, I'll be happy to send them a copy. That was up to date as of January of last year.

The significance of virus in water supplies maybe over-stated. It may not be. I really don't know. The virus which is known to be transmitted by water route is infectious hepatitis, which appears to be more resistant to our treatment than other viruses; but, again, we don't know that because we can't culture hepatitis and detect it. However, there are a lot of studies which have indicated that one virus particle or plaque-forming unit as it is referred to - can cause an infection, if not necessarily a manifestation of the disease; and apparently people who are doing cancer work seem to think there is a no threshold for cancer. If a virus does cause cancer, one of them might be sufficient, and you won't know until twenty years from now.

If we do come up with one virus plaque-forming unit per hundred gallons and you drink two liters of water a day, which is half a gallon, then you will be drinking one virus every two-hundred days. The question is - how significant is that? Would you want to drink one virus every two-hundred days?

(Edited by John K. Jacobs of Los Angeles City Department of Water and Power.)

SUMMATION AND CLOSING COMMENTS

By

Jean Auer - Member, California State Water Resources
Control Board

Presented at the Third Annual Conference, WATERCARE
"Conservation Through Reclamation", June 10-11, 1976,
Pepperdine University, Malibu Campus

SUMMATION AND CLOSING COMMENTS

by

Jean Auer

Member, California State Water Resources Control Board

I don't really have a lot to say - I've listened very carefully and I have some questions of you. One of them is, "What do we get out of a conference like this and the conference on wastewater reclamation at Davis a year ago?" Let me tell you what I think we get out of it. I think we get out of it the stimulation for water quality criteria regarding public health. We are now finally going to have hearings held by the State Health Department on criteria for groundwater recharge, and I urge you to have your input at those hearings. What else do we get? I think we got the stimulation to get together the panel of experts on groundwater recharge with reclaimed water. I think they did a great service to California by showing what the research needs are. And, finally, I think the most important thing we get out of this conference and the wastewater reclamation conference at Davis, is that the State Water Resources Control Board has finally decided to move forward in the development of water reclamation; and I think that is very significant.

The State Water Resources Control Board has had two major obstacles to the development of water reclamation: statewide approach with guidelines and principles, and an action plan. The Board is now fully committed to adopting guidelines, principles, and an action plan for water reclamation. In that action plan, we are going to make a new commitment through the grants program, to help fund some of the research and pilot projects that you need, and also to find where the gaps are so that we can have demonstration projects that show reclamation can work.

What I hope to offer the Board with the development of a SWRCB policy and an action plan on water reclamation is a process that we can all accept that pits reclamation projects against non-reclamation projects, so we figure out which project is the best. I expect some new approaches to cost-effectiveness, some relooking at water-rights decisions, and some real promoting by Department of Health to establish the criteria required of them by the Porter-Cologne Act. We <u>will</u> find a process whereby reclamation is reviewed with a mere equitable chance in this multibillion-dollar public works program (upgrading wastewater treatment) we all are embarked upon in California. I don't believe you can treat wastewater to the quality required for disposal and not find it cost-effective to reuse it for some beneficial use. I can't define all of the uses that will be made or the locations of these uses at this time, but that's one of the tasks we will accomplish through our action plan.

I urge all of you to follow the SWRCB water reclamation policy and action plan development. The Task Force will complete the development of this work in August. Then copies of the document will be sent out to interested parties for hearings in October. We have committed ourselves to adoption of this water reclamation policy with its guidelines and principles, and to the action plan, by end of this calendar year.

I want to speak specifically about some aspects of the water reclamation policy and action plan. One relates to the 208 Planning process and the Phase II of the Basin Plans. I think it would be fruitless to assume that if you involve yourself in 208 Planning and/or Basin Plan, Phase II, that you are going to change some of the standards. You may cause that to be considered, though; since in the case of water reclamation, I am closely following the existing policies of the SWRCB and individually informing other Board members of my interpretations. In particular, there has been a concern about the nondegradation policy. I think I can now safely say we have unanimously concluded that the nondegradation policy has exceptions in it now. We don't have to change the nondegradation policy; we are going to address how the nondegradation policy fits in with the wastewater reclamation action plan. But we don't think, and some people contend bitterly that's what has happened - that their reclamation projects have been shot down because of the nondegradation policy. My answer to that is - there's an appeal's process. If the Regional Board does not allow a reclamation project because of the nondegradation policy, then it should be appealed to the State Board. We have not had one reclamation project, that I know of, appealed to us because it was turned down due to the nondegradation policy. There are lot of ghosts as well as real problems. There are people who sometimes look to be defeated; and I think you have enough genuine obstacles to overcome in the development of water reclamation without looking for ones that I don't feel really exist - and I don't say that glibly.

There are some water rights problems that will be dealt with from the Board's point of view because we are in charge of water rights as well as water quality. There is a concern for reclamation which takes away a downstream user's water through reuse. Those of you in Southern California don't have as much concern about this as those of you in Northern California, but it is a genuine problem. One of our Board members has said he is interested in adopting a policy which states that if State Water Resources Control Board finds that there is reclaimed water of a quality for a particular beneficial use, it would be required that use be made with the reclaimed water available in lieu of water from an existing water right or water contract. This is obviously going to be controversial, but it is being discussed.

With regard to any particular water reclamation project in this state, I have found it better to completely divorce myself from such. I was following individual reclamation projects quite closely at one time. I feel that as the link to this Task Force it would be, to put it mildly, inappropriate for me to track and promote any particular reclamation project. I think it could look as though I were trying to set the tone for certain end result because I had pet projects, and even though that may not be true, I don't want that to seem that way; and so I hope that those of you who had individual projects that you are very much anxious to set forth - go through the process. We are thinking - one of the alternatives in this action plan is to have a subgroup on the staff that deals entirely with wastewater reclamation. That's another one of the things that has been promoted.

The last thing I really have to say about the water reclamation policy and action plan is - I don't think what we go to hearing with is what we will come out with. And that's up to you, and I cautioned the Task Group, because when people give birth to a document like this, they don't like to change it. I have a different feeling; I think you come out with a document that you think is really appropriate. But you keep an open mind - or else don't bother going through the hearing process. Anyone who is not in the program, I feel an obligation to listen to you and keep my mind open, so that you have something really important; it might have some influence on what the final result is. I have been to hearings where I felt no one was listening. I'm sure you have. I have seen beautifully orchestrated EIRs; I have seen beautifully orchestrated standards - and I won't be specific; and I've seen all kinds of things that are set out and there is created an aura of public input, and it is meaningless. But, I tell you now that you have an opportunity before the end of this year to influence the final results of the direction of our Board is going to take.

I'll close with something I started with at the reclamation class at Davis, and that is, I'm going to paraphrase a man named Marshall McCluen, and he describes Western Society as having two modes of thinking: one is called "linear" and one is called "circular." The "linear" mode of thinking is the A to the B to the C. The water supply - to the use of the water - to the outfall. I really believe our society is finally going to stop looking at water resources in "linear" fashion, and I hope take a "circular" view and try and think of the A, the water supply; the B, the treatment; the C, the discharge; not in a "linear" fashion, but as an interrelated "circular" fashion. I hope you will all encourage the people you represent to join you in this "circular" view things, because I do think that I'm talking to the audience that already is in that direction.

(Edited by John K. Jacobs of the Los Angeles City Department of Water and Power.)

MINUTES OF ANNUAL MEETING OF MEMBERS OF CALIFORNIA ASSOCIATION OF RECLAMATION ENTITIES OF WATER (WATERCARE) - JUNE 11, 1976, MALIBU, CALIFORNIA

Lloyd C. Fowler, President

Neil M. Cline, Secretary

Associate Members and Alternate Representatives

Presented at the Third Annual Conference, WATERCARE
"Conservation Through Reclamation", June 10-11, 1976,
Pepperdine University, Malibu Campus

MINUTES OF ANNUAL MEETING OF MEMBERS
OF
CALIFORNIA ASSOCIATION OF RECLAMATION ENTITIES OF WATER
(WATERCARE)

June 11, 1976, Malibu, California

Following the Third Annual Conference of the California Association of Reclamation Entities of Water (WATERCARE) held June 10 and 11, 1976 at Pepperdine University's Malibu campus, President Lloyd C. Fowler called the Annual Business Meeting of the general membership to order at 1:35 p.m., June 11, 1976, in Elkins Auditorium, Pepperdine University Malibu Campus, Malibu, California. Representing member agencies were the following Representatives and Alternate Representatives:

George W. Adrian, Representative, City of Los Angeles Department of Water and Power
Dr. Linda K. Phillips, Representative, Goleta County Water District
H. W. Stokes, Representative, Las Virgenes Municipal Water District
Lloyd C. Fowler, Representative, Santa Clara Valley Water District
Polly O. Smith, Representative, Marin Municipal Water District
Neil M. Cline, Representative, Orange County Water District
Dave Perkins, Alternate Representative, East Bay Municipal Utility District
Earl L. Lenahan, Alternate Representative, Alameda County Water District

Associate Members present included:

William E. Warne, Associate Director
Robert Y.D. Chun, Charles Kleine, and Dr. Donat B. Brice, California Department of Water Resources
Dr. Joseph F. Brown, Cupertino Sanitary District
Max S. Kreston, Metcalf & Eddy
George A. Crum, Southern California Edison Company
Gary Eikermann, Jack G. Raub Co.
Bill Seeger, Kennedy Engineers
Joan Kerns, Montecito County Water District
Chuck Milam, Central and West Basin Water Replenishment District
John G. Joham, Central and West Basin Water Replenishment District
Moshe Uziel, Consoer Townsend and Associates
L. A. Moldenhauer, CH2M Hill

Member agency Alternate Representatives present also included:

Nick Richardson, Orange County Water District
Jack Jacobs, City of Los Angeles Department of Water and Power

Participating also at the meeting were Gary McFarland, Goleta County Water District, William F. Hurst, Irvine Ranch Water District; Robert M. Hagan, University of California, Davis; Bill Bardin, Montgomery Engineers; Mrs. William E. Warne; and Violet Enander, Santa Clara Valley Water District, WATERCARE Treasurer, and Barbara Barber, Orange County Water District, Recording Secretary.

The Recording Secretary was requested to note in the Minutes that several Associate Members participating in the Annual Conference were not present at the Business Meeting in order to take the tour of Las Virgenes Municipal Water District Tapia Water Reclamation Plant.

ELECTION OF DIRECTORS

President Fowler presented the Nominating Committee's recommendation that Directors George Adrian, Linda Phillips and Will Stokes be re-elected for terms of 1976-1979. There were no nominations from the floor and the following action occurred:

MOTION NO. 76-6-132 Upon motion by Neil M. Cline, seconded by Joan Kerns and carried, nominations for WATERCARE Directors are hereby closed and Directors George Adrian, Dr. Linda Phillips and H. W. Stokes are hereby re-elected for terms expiring at the 1979 Annual Meeting.

ELECTION OF ASSOCIATE DIRECTOR AND ALTERNATE ASSOCIATE DIRECTORS

Associate Director William E. Warne's suggestion that WATERCARE make provision for an Alternate Associate Director to represent Associate Members at Board meetings in the Associate Director's absence had been acted on affirmatively at the April 21, 1976 Board meeting at which, by Motion No. 76-4-127, Associate Member Arthur J. Inerfield was appointed Alternate Associate Director to serve until the June 1976 Annual Meeting. Before consideration of additional nominations for Associate Director and Alternate, Mr. Warne suggested that the Associate Members also consider the nomination of a Second Alternate Associate Director, and action was taken as follows:

MOTION NO. 76-6-133 Upon motion by John Joham, duly seconded and carried, William E. Warne is hereby nominated Associate Director to WATERCARE for 1976-77; Arthur J. Inerfield is hereby nominated First Alternate Associate Director and William Seeger is hereby nominated Second Alternate.

There being no further nominations, elections for Associate Director and Alternates were concluded as follows:

MOTION NO. 76-6-134 — Upon motion by John Joham, duly seconded and carried, William E. Warne is hereby re-elected WATERCARE Associate Director, and Arthur J. Inerfield and William Seeger are hereby elected First and Second Alternate Associate Directors, respectively.

ACCEPTANCE OF NEW ASSOCIATE MEMBERS

MOTION NO. 76-6-135 — Upon motion by Associate Director Warne, duly seconded and carried, the following applicants for Associate Membership in WATERCARE are hereby accepted:

Mr. Robert T. Misen
Mr. George A. Crum
Dr. Joseph F. Brown
Biological Water Purification of California, Inc.
Mr. J. Lynn Hartford
Mr. Gary Eikermann

APPROVAL OF MINUTES

MOTION NO. 76-6-136 — Upon motion by William E. Warne, seconded by John Joham and carried, the Minutes of the WATERCARE Board of Directors meeting held April 21, 1976 are hereby approved.

APPROVAL OF TREASURER'S REPORT

MOTION NO. 76-6-137 — Upon motion by Mrs. Polly Smith, seconded by William E. Warne and carried, the Treasurer's Report dated May 31, 1976 is hereby approved.

APPROVAL OF FISCAL YEAR 1976-77 BUDGET

President Fowler opened discussion of the proposed FY 1977 Budget by referring to Associate Member Lawrence R. Michaels' letter suggesting that dues for Associate Members be raised to $25 annually to more equitably reflect their share of costs of preparing and mailing WATERCARE Minutes, Agendas, NEWSLETTERS, etc. This letter had been mailed to all members prior to the meeting for comment, and suggestions received prior to and at the meeting included:

1. Development of two classes of Associate Memberships--one for Associate Members who wanted to receive all mailings and one for Associate Members who preferred not to receive this material.

2. Development of different Associate Membership rates for individuals joining through firms vs. individuals joining on their own behalf.

3. Recognition of Associate Memberships through firms involved with the water industry vs. members not associated with the industry and therefore not able to deduct their dues from their income taxes.

In rebuttal, it was noted that Associate Members joining through their firms participated at meetings at the firms expense and contributed greatly to the organization. President Fowler agreed that WATERCARE wanted as many members as possible and that he did not think it advisable to increase the Associate Members' dues at this time.

Action occurred as follows:

MOTION NO. 76-6-138 Upon motion by H. W. Stokes, seconded by Dr. Linda Phillips and carried, discussion of WATERCARE's FY 1977 Budget is hereby deferred to later in the meeting.

REDEDICATION OF WATERCARE

Associate Director William E. Warne addressed the assembly to urge that the membership assess the association's goals and activities and rededicate itself to its original purposes. (Mr. Warne's presentation is attached to these Minutes as Exhibit A.) Mr. Warne concluded by stressing the importance of sponsorship of projects to further wastewater reclamation for reuse, referring to and appealing for support of the project submitted at the April 21 Board meeting by the Orange County Water District for organic identification.

There was lengthy discussion of the association's purposes and rededication, and of support of and endorsement of the OCWD and other projects, after which the following action was taken:

MOTION NO. 76-6-139 Upon motion by George Adrian, seconded by Dr. Linda Phillips and carried, WATERCARE's FY 1977 Budget is hereby reinserted on the Agenda for consideration at this time.

MOTION NO. 76-6-140 Upon motion by William Warne, seconded by George Adrian and carried, the Budget of the California Association of Reclamation Entities of Water for Fiscal Year 1977 is hereby approved as submitted and attached to these Minutes, with the addition of a commitment to contribute $12,000 to the Orange County Water District project "Organic Identification and Virus Monitoring in Orange

County" provided that funding can be arranged; and, further, that an ad hoc committee be appointed to investigate methods for funding this project.

ELECTION OF AUDITOR

MOTION NO. 76-6-141 Upon motion by William E. Warne, seconded by George Crum and carried, Dave Perkins, East Bay Municipal Utility District, is hereby re-elected Auditor to examine and report on WATERCARE's books at the close of Fiscal Year 1977.

President Fowler noted that the Association's Bylaws had been amended to permit submittal of the Audit Report within two months after the close of the fiscal year rather than at the Annual Meeting. This amendment will enable the Auditor to review the association's books after year-end closing, June 30, and take into account checks outstanding at the close of the fiscal year. The 1976 Audit Report will therefore be presented at the August 1976 Board Meeting.

COMMITTEE REPORTS

President Fowler reported that Dr. Linda Phillips had been appointed Chairman of the Legislative Committee and several members newly appointed to serve on this Committee. Discussion of committee appointments led to the following action:

MOTION NO. 76-6-142 Upon motion by H. W. Stokes, seconded by Dr. Linda Phillips and carried, it is hereby agreed that Associate Director Warne's call for rededication of WATERCARE be circulated among Directors, Members, and Associate Members of the organization to request their assistance in revitalizing the agency by active participation on committees of their preference.

Membership Committee

President Fowler noted that to increase WATERCARE's viability it was important to bring new Members and Associate Members into the organization. Members are encouraged to make personal appeals for new member agency and Associate Membership involvement, and additional membership solicitations will be an important matter of business during the next year.

Legislative Committee

1. A.B. 3793, S.B. 1947

Dr. Phillips reported that A.B. 3973 has passed the Assembly by unanimous vote and is now before the Senate Agriculture and Water Resources Committee. This bill permits any supplier of water for municipal use to require installation of water saving devices as a condition of new service. S.B. 1947, a similar bill which would apply to county water districts, has passed the Senate Water Committee and is now on the Senate Consent Calendar.

2. ACR 164

Dr. Phillips reported that ACR 164, which requested the State Water Resources Control Board to give priority in the processing of grant applications under the Clean Water Bond Law of 1970 to projects for the reclamation of wastewater during the balance of Calendar Year 1976, has been dropped.

3. ACR 165

ACR 165 calls for State agencies to recommend and adopt water conservation practices. Dr. Phillips noted that this resolution has passed the Assembly by unanimous vote, has been passed by the Senate Agriculture and Water Resources Committee, and is presently before the Senate Finance Committee. Hearing date has not been established. Action occurred as follows:

MOTION NO. 76-6-142 Upon motion by Dr. Linda Phillips, seconded by Neil M. Cline and carried, ACR 165 requesting State agencies to review their programs and activities to ascertain areas where water conservation practices may be adopted and calling for earliest practical adoption of such conservation practices, is hereby strongly endorsed by the California Association of Reclamation Entities of Water.

COMMENDATION OF LAS VIRGENES MUNICIPAL WATER DISTRICT AND PEPPERDINE UNIVERSITY

President Fowler noted that the meeting was running overtime and should consider adjournment in order that attendees wishing to do so could tour the Tapia Plant. Prior to adjourning, those present expressed their appreciation for the excellent program and conference arrangements accomplished by the efforts of Will Stokes, Conference Chairman; George Adrian, Eugene Bowers and John Joham, Conference Committee members; and the staff of Las Virgenes Municipal Water District, Conference Host. The following actions were taken:

MOTION NO. 76-6-143 — Upon motion by Neil M. Cline, duly seconded and unanimously carried, it is hereby agreed that a resolution be prepared thanking and commending the Conference Committee of WATERCARE's Third Annual Conference.

MOTION NO. 76-6-144 — Upon motion by Neil M. Cline, seconded by Dr. Linda Phillips and carried unanimously, it is hereby agreed that a a resolution be prepared thanking Pepperdine University and its staff for their participation in WATERCARE's Third Annual Conference.

PROCEEDINGS, THIRD ANNUAL CONFERENCE

MOTION NO. 76-6-145 — Upon motion duly made, seconded and carried, it is hereby agreed that the Proceedings of the Third Annual Conference of WATERCARE shall be printed for distribution, and a sum of approximately $250 is hereby authorized for costs of printing.

ADJOURNMENT

There being no further business, the Annual Meeting of Members of WATERCARE was adjourned at 3:30 p.m.

Lloyd C. Fowler, President

Neil M. Cline, Secretary

LET US REDEDICATE 'WATERCARE' TO ITS TASKS

by William E. Warne, Associate Director

In the life of any organization like WATERCARE, there comes a time for reappraisal, a hard look at the future, and a resetting of old goals or a rededication and renewal on the part of the members to the purposes originally set down in the charter. I think we have reached in WATERCARE the point for just such a reappraisal and rededication. Unless we undertake this self-analysis and unless we can thereby release a new burst of energy, there is danger that WATERCARE will drift off into the doldrums of calm waters where so many other organizations like ours are hove to. The members will loll around waiting for each succeeding annual meeting, as though a cocktail party on deck were fulfillment of the purposes of launching the ship.

As one who helped to launch WATERCARE, I would rather see our organization become the tug-boat that at the outset it was felt was required to pull our programs against the resistance of the tides in public attention that ebb and flow about the business of water reclamation. There is a current of emotional opposition to wastewater reuse that WATERCARE has to buck. Our craft was not designed for a mere pleasure cruise.

In three years WATERCARE has made great headway. It has attracted 19 public agency members, some of them the very largest and among them the most alert and active in the State. WATERCARE has a large body of Associate members, whose names would make a roster of California water leaders. WATERCARE has raised its voice effectively--even when no other organization has--on issues related to water conservation, water reclamation, and wastewater reuse as a means of extending and improving California's water supplies. WATERCARE has encouraged its member agencies to undertake and to participate in research vital to the promotion of wastewater reclamation and reuse. WATERCARE has cooperated with other organizations, such as the National Water Supply Improvement Association, the Association of California Water Agencies, and the American Water Works Association, which have similar objectives. These are positive achievements.

My fear is that WATERCARE is now being becalmed. New impetus is required to avoid succeeding too little in the future. There is a loss of momentum at the present.

The organizers of WATERCARE had a unique, bright idea. It was this:

> WATERCARE will sponsor and assist its interested members in sponsoring, financing and conducting research needed in the field of water reclamation to make reuse of wastewaters a practicable means of improving and extending water supplies in California.

EXHIBIT A

The conception was that one member with a problem and an inspiration of how to research its solution would apply to WATERCARE, which would examine, appraise, and endorse if appropriate the proposal, and if the proposal were worthy, would participate in the study with its own resources or organize groups of members into participating consortia.

WATERCARE has succeeded in assisting in obtaining at the Federal level and at the State level authorizations for aid programs in water reclamation and reuse for water supply improvement. As a matter of fact, on Tuesday of last week our electorate approved a $175 million bond issue for clean water supplies. Note-- WATERCARE was the first advocate of this. We went to the Legislature and had them introduce the first bill. It failed in that session, succeeded later, and now it has been approved as a bond issue. Funding has been short, but there are some funds being made available. WATERCARE, however, has not succeeded very well in organizing concortia of its members and activating many new research thrusts.

My fear is that WATERCARE may never reach the point of full effectiveness if it continues to rely exclusively on the contributed resources of its leaders and their agencies, which have very generously backed our leaders so far. I do not consider this largess a sound base for the future.

I propose that WATERCARE accept the challenge that it originally presented to itself and to its members. I propose a rededication to our original plan. I propose that WATERCARE members assess themselves, or those among them who are interested in specific projects, to finance, sponsor, and conduct several of the projects that are in formative stages, including the one respecting identification of organics that was proposed by Neil Cline and the Orange County Water District. If the budget is too small, raise the needed funds as was originally intended by soliciting wide-spread contributions from individual members who will thus buy into the project consortium.

I also propose that the WATERCARE budget be increased in order to carry the costs of an office and at least half-time of a competent executive manager. Let us take WATERCARE out of the freebie class, in which a few agencies pay unduly large proportions of the operating costs.

I believe that decisions to do these things will excite new interest and be an enticement to attract new memberships, which will help to defray the added costs. My belief is that more agencies will participate in a really active organization than in one that makes a good start and then begins to coast along.

I call for a rededication to WATERCARE and its objectives and purposes of those who are interested in water reclamation and the application of the new water sciences to the solution of California's increasingly difficult water problems.

The alternative to action now may be collapse later.