UNITED STATES

DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

WATER RESOURCE RESEARCH GRANT PROGRAM PROJECT DESCRIPTIONS, FISCAL YEAR 1986

By Branch of Research Grants and Contracts

U.S. GEOLOGICAL SURVEY

Open-File Report - 86-548

Reston, Virginia

1986

UNITED STATES

DEPARTMENT OF THE INTERIOR

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U.S. GEOLOGICAL SURVEY

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INTRODUCTION

In January 1985, the U.S. Geological Survey (USGS) was assigned responsibility for administering the functions of the Water Resources Research Act of 1984 (Public Law 98-242). Section 105 of the Act authorizes funds to be appropriated for the purpose of making research grants, on a fund-matching basis, to qualified groups as defined in the legislation.

The program was funded at $2.543 million for fiscal year 1985. For these funds there were 368 applications requesting a total of approximately $33 million. From this group, 24 projects were selected for support. These were described in U.S. Geological Survey Open-File Report 85-687, "Water Resources Research Grant Program Project Descriptions Fiscal Year 1985."

For fiscal year 1986, the amount available was $4.767 million. After the publication of Announcement No. 7127 on December 2, 1985, 299 grant applications were received with requests totaling about $31 million. The selection process yielded a total of 43 projects for support.

For both fiscal years 1985 and 1986, a summary of funding by topic is given in Table 1. A summary of funding by organization type, such as academic institutions, government entities (including water districts and river basin commissions), and private industry is given in Table 2. In Table 3 the proposals received are listed according to research category and funding requested. Table 4 summarizes the distribution of all proposals received by type of submitting organization.

This report provides information on each of the 43 projects funded in fiscal year 1986 under section 105 of Public Law 98-242 and includes the grant number, the project title, the performing organization, the period of performance, and a brief description of the research to be done.

Table 1.--Funding by research topic

Fiscal Year 1985

Topic	Number of Projects	Federal Funds ($)	Matching Funds ($)	Total Funds ($)
Ground-Water Management	8	697,324	848,130	1,545,454
Surface-Water Management	7	736,847	743,544	1,480,391
Systems Operation/Planning	2	168,445	169,537	337,982
Irrigation Management	3	290,518	326,416	616,934
Desalination/Reuse	2	292,770	302,379	595,149
Economic/Legal/Institutional	1	47,881	47,882	95,763
Agricultural Drainage	1	139,827	139,827	279,654
Climate Variability	0	0	0	0
Totals	24	2,373,612	2,577,715	4,951,327

Fiscal Year 1986

Topic	Number of Projects	Federal Funds ($)	Matching Funds ($)	Total Funds ($)
Ground-Water Management	14	1,471,284	1,599,783	3,071,067
Surface-Water Management	6	672,074	705,295	1,377,369
Systems Operation/Planning	2	225,862	225,950	451,812
Irrigation Management	3	335,564	354,673	690,237
Desalination/Reuse	8	1,020,710	1,039,800	2,060,510
Economic/Legal/Institutional	6	618,860	694,824	1,313,684
Agricultural Drainage	0	0	0	0
Climate Variability	4	418,021	430,949	848,970
Totals	43	4,762,375	5,051,274	9,813,649

Table 2.--Funding by type of submitting organization

Fiscal Year 1985

	Number of Projects	Federal Funds ($)	Matching Funds ($)	Total Funds ($)
Academic Institutions	20	1,942,129	2,058,837	4,000,966
Government (non-Federal)	2	236,011	320,012	556,023
Industry	2	195,472	198,866	394,338
Totals	24	2,373,612	2,577,715	4,951,327

Fiscal Year 1986

	Number of Projects	Federal Funds ($)	Matching Funds ($)	Total Funds ($)
Academic Institutions	39	4,342,963	4,581,460	8,924,423
Government (non-Federal)	1	162,295	203,998	366,293
Industry	3	257,117	265,816	522,933
Totals	43	4,762,375	5,051,274	9,813,649

Table 3.--Proposals received and funding requested by research category

Fiscal Year 1985

Research Category	Number of Proposals	Federal Funds ($)	Matching Funds ($)	Total Funds ($)
Aspects of the Hydrologic Cycle	102	8,907,698	9,197,110	18,104,808
Supply & Demand for Water	10	781,935	782,238	1,564,173
Demineralization of Saline & Impaired Waters	11	1,171,155	1,473,398	2,644,553
Conservation & Best Use of Water	25	2,225,640	3,165,285	5,390,925
Reuse of Water	22	2,491,369	2,350,544	4,841,913
Depletion & Degradation of Ground Water	88	7,526,198	7,787,121	15,313,319
Improvements in Water Productivity	21	1,919,054	2,014,686	3,933,740
All Other Aspects of Water Usage	89	7,699,254	8,017,871	15,717,125
Totals	368	32,722,303	34,788,253	67,510,556

Fiscal Year 1986

Research Category	Number of Proposals	Federal Funds ($)	Matching Funds ($)	Total Funds ($)
Aspects of the Hydrologic Cycle	65	6,938,834	6,568,233	13,507,067
Supply & Demand for Water	16	1,398,507	1,428,238	2,826,745
Demineralization of Saline & Impaired Waters	16	1,861,867	1,829,359	3,691,226
Conservation & Best Use of Water	23	2,338,675	2,444,813	4,783,488
Reuse of Water	29	3,030,060	3,177,541	6,207,601
Depletion & Degradation of Ground Water	81	8,407,525	8,513,559	16,921,084
Improvements in Water Productivity	41	4,365,381	4,610,449	8,975,830
All Other Aspects of Water Usage	28	2,875,015	2,731,466	5,606,481
Totals	299	31,215,864	31,303,658	62,519,522

Table 4.--Proposals received and funding requested by type of submitting organization

Fiscal Year 1985

	Number of Proposals	Federal Funds ($)	Matching Funds ($)	Total Funds ($)
Academic Institutions (84.2%)	310	27,102,970	27,628,745	54,731,715
Government (non-Federal) (8.7%)	32	2,980,630	3,204,536	6,185,166
Industry (7.1%)	26	2,638,703	3,955,698	6,594,401
Totals	368	32,722,303	34,788,979	67,511,282

Fiscal Year 1986

	Number of Proposals	Federal Funds ($)	Matching Funds ($)	Total Funds ($)
Academic Institutions (91%)	272	28,292,771	28,205,373	56,498,144
Government (non-Federal) (3.3%)	10	1,172,935	2,089,714	3,262,649
Industry (5.7%)	17	1,750,158	1,711,571	3,461,729
Totals	299	31,215,864	32,006,658	63,222,522

PROJECT DESCRIPTIONS

GROUND-WATER MANAGEMENT

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1279
PROJECT TITLE:	Evaluation and Modeling of Volatile Organic Vapor Transport in the Unsaturated Zone for Ground-Water Quality Protection
PERFORMING ORGANIZATION:	Utah State University Logan, UT 84322-8200
PRINCIPAL INVESTIGATOR:	R. Ryan Dupont
DATES:	September 1, 1986, through August 31, 1988

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. The introduction of hazardous materials into the environment is of growing concern as the extent of contamination and its impact on public health and safety has become more clearly documented. Vapor movement in the unsaturated zone is an important component of contaminant mobility which has been investigated only on a limited scale for many compounds of significant environmental concern. This project will investigate the quantitative nature of vapor partitioning and movement of contaminants in the unsaturated zone by using laboratory and pilot-scale simulated aquifers . One-, two, and three-dimensional vapor profiles will be investigated with respect to source strength for surface and subsurface contaminants for a range of soil materials, and a multiphase unsaturated-flow model will be evaluated for its use in predicting the fate of volatile hazardous constituents in the unsaturated zone.

2. Contribution to problem solution. The proposed research will provide information that allows the modeling and prediction of the movement of volatile contaminants in the unsaturated zone. Relations of contaminant source location and strength to vapor concentration and spatial distribution in the unsaturated zone will be developed. Results will provide a methodology for evaluation and prediction of the nature and extent of contaminant movement in the vapor phase from contaminated aquifers as well as from surface deposits, spills, etc., to uncontaminated ground-water supplies.

3. Objectives. The specific objectives of the proposed research are as follows:

   a. To develop a quantitative modeling approach to describe vapor movement in the unsaturated zone from various source strengths and configurations.

b. To refine a methodology for the delineation of contaminant-vapor profiles in the unsaturated zone and relate such profiles to source strength and aquifer conditions.

c. To evaluate the three-dimensional nature of the movement of volatile contaminants from areal and point sources on a pilot scale for the extension of laboratory column data to simulated field conditions.

4. Approach. Synthetic mixtures of volatile and semi-volatile hazardous constituents found in petroleum products and in wastes from industries that use land treatment for the disposal of their wastes (petroleum, wood preserving, etc.) will be used in the experiments. Waste mixtures and actual soils representing a range in soil characteristics will be used in laboratory partitioning, column, and pilot-scale aquifer experiments. Soil surface emission, vapor profile, and aquifer contaminant concentrations will be monitored over time to provide information regarding the partitioning and dynamics of vapor transport following soil/aquifer contamination. Results will be evaluated using a multiphase, unsaturated zone contaminant transport model to identify the capabilities and limitations of the monitoring and modeling approaches utilized.

5. Result users. Results will be directly usable by the U.S. Geological Survey, the U.S. Environmental Protection Agency, and State and local health and environmental pollution control professionals, as well as by private companies and individuals for the prediction of contaminant vapor transport in the unsaturated zone for hazard potential assessment, source protection, and soil and aquifer remediation analysis.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1282
PROJECT TITLE:	Bacterial Transformations of Nitrate and Aldicarb (Temik) in Anoxic Ground Waters of Long Island
PERFORMING ORGANIZATION:	Suffolk County Department of Health Services Hauppauge, NY 11788
PRINCIPAL INVESTIGATOR:	Douglas G. Capone
DATES:	September 29, 1986, through September 28, 1989

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. Nitrate and aldicarb (Temik) are conspicuous contaminants of the Upper Glacial Aquifer of Long Island and persist under oxic conditions. Although the waters of much of the upper aquifer are aerobic, ground waters depleted in or devoid of oxygen are present on Long Island. The fate of these contaminants under anoxic conditions is unknown and may be quite different from their fate aerobically. Anaerobic bacteria play important roles in the cycling of nitrogen and carbon compounds (including organic contaminants) in terrestrial and aquatic environments. Denitrification, the anaerobic dissimilation of nitrate to nitrogen gas, has been shown to be a quantitatively important sink for nitrate in some sedimentary environments. Alternately, anaerobic bacteria can reduce nitrate to ammonium. Unique, bacterially mediated pathways exist for the anaerobic consumption of some organic contaminants.

2. Contribution to problem solution. The concentration and distribution of nitrate, oxygen, and other constituents have been well characterized in the Upper Glacial Aquifer. From oxic to anoxic parts of the aquifer, the speciation of nitrogen changes from predominantly nitrate to ammonium, evidence for dissimilatory reduction. Denitrification is likely concurrent, providing a sink for the nitrate contaminant. Concentrations of aldicarb and its persistent daughter products, aldicarb sulfoxide and aldicarb sulfone, have also been determined at various sites. Preliminary evidence has shown that aldicarb can be rapidly degraded anoxically, in contrast to its slow aerobic degradation.

3. Objectives. It therefore is proposed to undertake a study of bacterial processes that affect the levels of nitrate and aldicarb in the Upper Glacial Aquifer. Samples of ground waters and soils from the saturated zone will be collected. Direct determinations of rates of bacterial denitrification and dissimilatory reduction of nitrate to ammonium will be performed on freshly collected samples.

4. Approach. For denitrification, a sensitive gas-chromatograph-based enzyme assay, the C_2H_2 blockage procedure, will be employed. $^{15}NO_3^-$ tracer methods will also be used, and will additionally allow assessment of nitrification and the relative proportions of nitrate being denitrified and dissimilated to ammonium. To a limited extent, $^{13}NO_3^-$, available from the Brookhaven National Laboratory, will be used as a sensitive direct tracer for denitrification. Experimental manipulations will examine factors controlling rates of these transformations (e.g., effects of O_2, organic substrates). Direct estimates of rates of these processes performed on freshly collected samples will be compared to modelled estimates based on the concentration of nitrogenous species along transects of the aquifer through oxic/anoxic transition zones. Radionuclide chronologies will be used to provide precise time scales of flow down the hydraulic gradient along these transects and to characterize the reactivity of the aquifer. Similarly, rates of aldicarb degradation will be determined directly on samples collected from anoxic zones. A combination of high performance liquid chromatography, gas chromatography-mass spectroscopy and ^{14}C-tracer methods will be used to estimate degradation and mineralization rates, as well as to identify persistent daughter products. In situ concentrations of aldicarb and daughter products at sites of low or negligible oxygen concentration will be determined. The capacity for aldicarb to promote methanogenesis in these environments will also be considered.

5. Result users.
Although there is some indirect evidence, little is known of the contribution of bacteria to the transformations of contaminants in ground water. The results of this project will be of basic scientific interest and value in identifying the importance of native bacterial populations in aquifer environments. Furthermore, it will assist in determining more precisely the persistence of two environmentally significant ground-water contaminants.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1284
PROJECT TITLE:	In-Situ Control of Ground-Water Contaminants by Microbiological Processes
PERFORMING ORGANIZATION:	Montana State University Bozeman, MT 59717
PRINCIPAL INVESTIGATOR:	William G. Characklis
DATES:	September 22, 1986, through September 21, 1988

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. This proposed research addresses problems of ground-water quality in systems where microbial and hydraulic processes significantly influence the migration of organic contaminants.

2. Contribution to problem solution. Because this work is interdisciplinary in nature, laboratory experimentation by investigators from two institutions--Montana State University (MSU) and Johns Hopkins University--will be coordinated over a two-year period. Research conducted by MSU will provide an improved understanding of the interaction between subsurface biological and hydraulic processes and the transport and fate of contaminants in ground water. Related research conducted at Johns Hopkins University will attempt to evaluate the influence of transport, attachment, and surface growth of microorganisms on biotransformation of organic contaminants in porous media.

3. Objectives. This project will provide information on how to introduce foreign bacteria into an aquifer to achieve bioreclamation and on factors influencing the placement and development of attached subsurface microbial activity to maximize interaction with organic contaminants.

4. Approach. The basic approach will be to operate porous-media flow reactors with defined mixed cultures. The bacteria will be cultivated from mature biofilms that are utilizing several halogenated aliphatic and aromatic compounds under aerobic and anoxic conditions. The influence of microbial transport, attachment, and activity as a function of cell concentration, nutrient supply, and porous-media characteristics on the biotransformation of halogenated compounds will be measured. The results of this research are expected to have important impacts in the understanding of the fate of organic contaminants in the environment. The knowledge will be applied to develop subsurface biological processes in the field to achieve significant in-situ treatment and aquifer restoration. Accordingly, at the conclusion of this

study, a field demonstration project will be designed to test the feasibility of using engineered microorganisms foreign to an aquifer to detoxify hazardous organic compounds. Site location, project design, and operation procedures will be chosen in collaboration with project consultants and others who are directly associated with specific ground-water contamination sites around the U.S.

5. Result users. This research will benefit regulatory agencies in establishing the long-term fate of organic contaminants and appropriate treatment standards and technology. The water-supply industry and ground-water management programs will also benefit from expanded knowledge of contaminant transport and fate.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1287
PROJECT TITLE:	Optimization of Remedial Programs for Contaminated Ground-Water Supply Systems: Deterministic and Stochastic Analyses
PERFORMING ORGANIZATION:	Cornell University Ithaca, NY 14853
PRINCIPAL INVESTIGATORS:	Christine A. Shoemaker Philip L-F. Liu
DATES:	September 30, 1986, through December 30, 1988

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. The main objective of this project is to develop a computationally feasible methodology that will enable us to determine the most cost-effective approach to reclaiming a contaminated aquifer.

2. Contribution to problem solution. The method being proposed uses a combination of finite-element methods (to describe the relationship of pumping and recharge to contaminant fate and transport) and an optimization method (to select the most economical combination of design and operational policies).

3. Objectives. The following objectives are expected to be achieved in this project:

a. A methodology will be developed to compute the most cost-effective way of reclaiming an aquifer considering all combinations of alternative designs (including the type and capacity of water treatment facility and the location and maximum capacity of pumping and recharge wells) and operation (including time-varying pumping and recharge rates and associated water treatment).

b. The methology developed will combine an optimization method that can explicitly integrate decisions about facility capacity and time-varying operational policies with a detailed description of contaminant transport including the impact of pumping on advection, diffusion, sorption, and degradation of the contaminant. A combination of differential-dynamic programming and finite-element methods will be used to achieve this goal.

c. The uncertainty associated with ground-water contaminant transport models will be incorporated directly into a stochastic optimization analysis so that the design and operation policies suggested by the optimization analysis are based on the recognition that the transport of contaminants cannot be predicted with absolute certainty.

4. Approach. Working with a hydrogeologic engineering consulting firm (Geraghty and Miller), the methodology developed will be applied to an actual field problem for which a contaminant transport model exists and for which remedial action plans have been made. The investigators will do the optimization analysis on this specific problem to see if the differential-dynamic programming/finite-element analysis actually does generate a facilities design and operation plan that is more cost effective over a long-planning period. This will enable one to compare the value of a "high-tech," computer-intensive analysis of the reclamation problem to the more conventional procedures currently in use by consultants. The optimization methodology developed does not require any additional data beyond that already collected for conventional analysis for costing alternative strategies and for development of a numerical model of contaminant transport. Hence the optimization methodology developed in this project is expected to be a relatively inexpensive way of maximizing the amount of information extracted from the expensive data collection effort.

5. Result users. Since contamination of ground water frequently occurs in densely populated areas, detoxification plans (especially those involving pumping) of a contaminated site may need to be considered within the context of the larger water-supply system. Hence, the methodology will consider both isolated ground-water contamination sites and the cleanup of sites that are affected by the operation of the larger water-supply system. This analysis will incorporate uncertainty in recharge and reservoir inflow to the water-supply system. These results will be useful to the U.S. Environmental Protection Agency or any other entity concerned with ground-water pollution problems.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1290
PROJECT TITLE:	Reductive Dechlorination and Bio-oxidation of Chlorinated Ethylenes and Methanes by Acetate-Utilizing Methanogens
PERFORMING ORGANIZATION:	Michigan State University East Lansing, MI 48824
PRINCIPAL INVESTIGATOR:	Stephen A. Boyd
DATES:	August 1, 1986, through July 31, 1988

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. The organic toxicants most commonly found in ground water are one- and two-carbon chlorinated aliphatic hydrocarbons such as tetrachloroethylene (PCE), trichloroethylene (TCE), carbon tetrachloride (CT), and chloroform (CF).

2. Contribution to problem solution. Recent research from several independent labs has shown the degradation of these chlorinated solvents to be more facile under anaerobic conditions especially in the presence of methanogens, and the degradative pathways are characterized by dechlorination and bio-oxidation. In general, dechlorinated products are less persistent and toxic than the parent compounds, but in some cases these products may present additional hazards as in the proposed generation of vinyl chloride from PCE and TCE. To date no one has identified the specific organism(s) responsible for anaerobic dechlorination of PCE, TCE, or CT, or for the bio-oxidation of CF. Our hypothesis, based on evidence from recent research, is that the acetate-utilizing methanogens, such as Methanosarcina and/or Methanothrix, are active organisms.

3. Objectives. The objectives of this proposal are to: (1) to determine if pure cultures of Methanothrix and Methanosarcina can dechlorinate PCE, TCE, and CT; (2) to determine if the same pure cultures can bio-oxidize CF to CO_2; (3) to demonstrate that vinyl chloride is a product of PCE and TCE dechlorination; and (4) to determine how some environmental parameters influence these transformations.

4. Approach. To test the hypothesis, pure cultures of Methanothrix sp., Methanosarcina mazei, and Methanosarcina barkeri will be exposed to PCE, TCE, CT, and CF. Dechlorinated products will be measured with purge and trap/gas chromatography methods and confirmed with gas chromatography/mass spectrometry. The bio-oxidation of CF will be studied by measuring the production of $^{14}CO_2$ from ^{14}C-labelled CF. The effects of growth substrate on rate of transformation will be studied by growing the Methanosarcina species on H_2/CO_2, methanol and methylamine. Both genera will also be grown on acetate. Identification of the specific bacteria responsible for the dechlorination and bio-oxidation of these compounds would be a major step 1) in understanding this process at a mechanistic level, 2) for studying environmental parameters which may affect this process, 3) for utilizing this potential biotechnology to detoxify contaminated aquifers, and 4) for predicting situations in which vinyl chloride could be released from PCE and TCE.

5. Result users. Any organization or agency interested in the degradation of refractory chlorinated organics.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1292
PROJECT TITLE:	The Removal of Toxic Heavy Metals from Contaminated Ground Water and Specific Industrial Waste Water by a Fungal Adsorption Process
PERFORMING ORGANIZATION:	University of Delaware Newark, DE 19716
PRINCIPAL INVESTIGATORS:	C. P. Huang Allen L. Morehart
DATES:	September 1, 1986, through August 31, 1989

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. Ground water is an important water resource for the State of Delaware. However, due to past careless practice in landfill operation and in the disposal of chemical wastes, some of the State's most important ground-water systems have been severely impaired by toxic chemical contaminants such as heavy metals. As a matter of fact, two of the landfills in New Castle County have been ranked highly in the Superfund's National Priority List. A survey of ground water from nearby wells has shown concentrations of heavy metals such as cadmium, lead, and mercury at hazardous levels. The removal of these toxic heavy metals from the contaminated ground water, the leachate and industrial waste-water sources is an important water-quality issue.

2. Contribution to problem solution. While the extent of ground-water contamination by toxic chemicals has reached an alarming level, both nation- and region-wide, no economically feasible method is available for the cleanup of contaminated ground water. This project will investigate an innovative fungal bio-adsorption process for the removal of heavy metals from contaminated water.

3. Objectives. The objectives of this project are: (a) to test the heavy-metal removal capacity of various fungal species; (b) to determine factors controlling the heavy-metal removal capacity of selected fungi; and (c) to design and establish reactors and operational parameters for the adsorption process.

4. Approach. It is very difficult to remove chemical contaminants at low concentrations. Chemical precipitation, reverse osmosis, and many other physical or chemical methods become inefficient when chemical contaminants are present at low concentrations. Adsorption processes can be an effective means to deal with such a situation. Many adsorbents have been suggested; these include activated carbon, activated alumina, synthetic ion exchangers, among other so-called low-cost adsorbents such as agricultural by-products, namely, tree bark, straw, peanut husk, peat moss, crushed coal, and insoluble starch xanthate (ISX). Many of these adsorbents, such as ISX and activated carbon are effective but complicated in application. Other adsorbents, such as fungi, which have layer-like polymeric structures that furnish activity sites for the adsorption of heavy metals, can be economically cultivated in mass quantities under various environmental conditions. This researchaims at the development of a bio-adsorption process for the removal of heavy metals from contaminated water.

5. Result users. The immediate beneficiary of this research project would be the general public. This process can be used to treat specific industrial waste waters, leachate, contaminated ground and surface waters, and agricultural runoff. The process to be developed can be used either as an emergency cleanup or daily treatment of contaminated ground water.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1296
PROJECT TITLE:	Computation of Three-Dimensional Advection-Dominated Solute Transport in Saturated Aquifers
PERFORMING ORGANIZATION:	Vanderbilt University Nashville, TN 37235
PRINCIPAL INVESTIGATOR:	Antonis D. Koussis
DATES:	September 1, 1986, through August 31, 1988

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. The proposed research will deliver an accurate and efficient computational tool for three-dimensional ground-water solute transport with grid sizes and resolution required for field applications.

2. Contribution to problem solution. The new method is specifically tailored to the demands of the computations in the troublesome high-gradient areas in the vicinity of sources and in the early stages of plume evolution, while maintaining its validity in the far-field. In advection-dominated transport, the accuracy of the far field computations deteriorates if the integration in the initial high-gradient areas fails to capture properly the migration of the contaminants.

3. Objectives. Historically, numerical solutions of advection-dominated problems have been plagued by nonphysical oscillations. The proposed method eliminates these oscillations without violating the underlying physical principles (by increasing dispersion either numerically or through use of arbitrarily high dispersion coefficients) and without resorting to expensive remedies (decrease of grid size or employment of computationally intensive algorithms).

4. Approach. The devised method solves the transport equation along natural coordinates (principal directions of hydraulic conductivity) by using a fractional time-stepping technique coupled with a highly efficient advection-dispersion step in the flow direction. This single advection-dispersion step is the key to the accuracy and efficiency of the new algorithm. It is based on an explicit, 2-point finite-difference scheme for the solution of the pure advection equation whose truncation error gives rise to numerical dispersion. The scheme accounts for the initially omitted gradient-type transport and eliminates the competition between the two dispersion mechanisms, a source of major numerical errors. At the same time, the scheme becomes unconditionally stable and second-order accurate.

5. Result users. By using principal-directions coordinates, the method can accomodate irregular solution domains naturally and efficiently. One to two orders of magnitude CPU-time savings over established methods can be expected, thus bringing 3-D simulation of subsurface-solute migration within the grasp of the practicing hydrogeologist.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1298
PROJECT TITLE:	Sunlight-Riboflavin Decontamination of Ground Water Containing Chemicals
PERFORMING ORGANIZATION:	University of Illinois Urbana, IL 61801
PRINCIPAL INVESTIGATOR:	Richard A. Larson
DATES:	September 29, 1986, through September 28, 1988

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. The principal water-related problem addressed by the proposed research is ground-water quality, specifically the problem of cleaning up existing contaminated ground waters. The proposed research investigates an improved method for removal of organic pollutants from contaminated ground waters by means of a novel treatment process combining sunlight and the naturally ocurring photosensitizer, riboflavin.

2. Contribution to problem solution. The proposed research will investigate, under both laboratory and field conditions, the feasibility of this new photochemically-based technique for the treatment of ground waters containing organic chemicals related to commonly used herbicides and insecticides. If the technique proves successful in removing these compounds, it would provide the basis for a useful and inexpensive process that could be widely applied in many areas of the country.

3. Objectives. The overall objective of the proposed research is to determine whether riboflavin, in the presence of sunlight, is a potentially effective agent for treatment of contaminated ground waters. Preliminary evidence suggests that the technique may have promise. It is anticipated that the results of this research will indicate that riboflavin-sensitized photolysis will be an effective method for the treatment of contaminated ground waters.

4. Approach. To achieve the overall objective, kinetic experiments will be carried out in the laboratory under carefully controlled conditions, using environmentally realistic concentrations of ground-water contaminants such as atrazine, aldicarb, 1-naphtol (a breakdown product of the insecticide Sevin), and 2,4,5-trichlorophenol (a breakdown product of the herbicide 2,4,5-T). In these experiments, the rate of destruction of the test chemical by riboflavin will be compared with that of direct photolysis (no riboflavin

added) as well as that of samples to which another photosensitizer (methylene blue) is added. Other experiments will determine the products formed in the photochemical reactions to get an indication as to whether more or less toxic types of compounds are being produced. Finally, the technique will be tested using actual ground waters.

5. Result users. It is anticipated that the results of the project will be made available in the forms of publications in primary journals, technical reports, and presentations at national or regional meetings of scientific societies such as the American Chemical Society. The results of the proposed research should provide valuable basic information about those classes of compounds that can successfuly be treated by sensitized photo-oxidation. This information could then be incorporated by scientists and water-treatment engineers into comprehensive processes possibly suitable for municipal treatment systems.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1299
PROJECT TITLE:	Nonequilibrium Adsorption During Reactive Contaminant Transport Through 3-D Heterogeneous Aquifers
PERFORMING ORGANIZATION:	University of Illinois Urbana, IL 61801
PRINCIPAL INVESTIGATOR:	Albert J. Valocchi
DATES:	September 19, 1986, through September 28, 1989

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. Development of scientifically sound management strategies for protecting the nation's precious ground-water resources must be based upon a solid understanding of contaminant behavior in natural subsurface environments. Adsorption is one of the most prominent chemical factors affecting the migration of hazardous pollutants. Adsorption reactions have been studied extensively in laboratory column experiments on relatively homogeneous soil samples; the important kinetic mechanism in those experiments involves microscopic transport from the flowing pore fluid to the soil-solution interface where the reaction occurs. However, the spatial variability of real field aquifers causes additional, higher-level kinetic limitations involving macro-scale mixing among zones of differing permeability. Data from recent field studies show significant deviations from equilibrium sorption behavior even for low velocity, natural gradient conditions. Deviations from local equilibrium behavior can result in early breakthrough and enhanced tailing of an advancing contaminant plume; therefore, proper understanding of kinetic phenomena is important for development of reliable solute-transport models.

2. Contribution to problem solution. The proposed research will result in improved theoretical understanding of the effect of field-scale soil permeability variations on the transport of adsorbing solutes.

3. Objectives. The overall goal of the research is to study the consequences of spatial variability for describing the movement and fate of adsorbing contaminants in realistic field situations. A primary objective is to identify field conditions where nonequilibrium behavior is governed by macroscopic mixing induced by spatial variability as opposed to microscopic kinetic processes. A macroscopic nonequilibrium model will be developed and tested using data from recent and ongoing field experiments.

4. Approach. Recent theoretical and field studies have indicated the paramount importance of small-scale heterogeneity for nonreactive solute behavior. The proposed research is unique since it focuses on the important implications of spatial variability for modeling reactive transport. The research approach is based upon the construction of a "numerical ground-water laboratory" involving three-dimensional models of fluid flow and adsorbing solute transport. A heterogeneous aquifer model will be constructed by treating hydraulic conductivity as a random field. The numerical laboratory will serve as a tool for investigating detailed research questions outlined in the proposal. The research will utilize the latest developments in multi-dimensional numerical modeling, along with the University of Illinois' outstanding computational resources.

5. Result users. The research will be most directly useful to the ground-water research community. By providing basic knowledge about the relationship between field heterogeneity and nonequilibrium adsorption phenomena, the research results will be beneficial to investigators developing predictive transport models for use by engineers in government, industry, and consulting. The results will help identify critical chemical reaction parameters and thus will be useful for development of field monitoring protocols.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1302
PROJECT TITLE:	Laser Fluorescence/Fiber-Optic Monitoring of Ground-Water Contaminant Biodegradation
PERFORMING ORGANIZATION:	Tufts University Medford, MA 02155
PRINCIPAL INVESTIGATOR:	Wayne A. Chudyk
DATES:	September 1, 1986, through August 31, 1987

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. The proposed research addresses the problem of a lack of useful tools to determine the existence and extent of biodegradation processes as they naturally occur in contaminated ground waters. Methods are needed for rapid and accurate measurement of organic-contaminant concentrations so that the changes in such concentrations indicative of biodegradations can be monitored closely enough for process control. The remote laser fluorescence/fiber optics ground-water contaminant detector (RFD) technique has been recently developed for monitoring aromatic organic ground-water contaminants. The RFD method uses fluorescence to measure contaminant concentration in-situ, and as such provides rapid accurate analysis required to follow biodegradation as it happens. An artificial aquifer constructed and used in the laboratory will be used to demonstrate the utility of the RFD method for monitoring biodegradation processes as they occur.

2. Contribution to problem solution. The proposed research will show the usefulness of the RFD method in following conditions under which biodegradation occurs. It will also demonstrate how RFD may be used to predict and control biodegradation processes as they may function at existing disposal or hazardous waste sites.

3. Objectives. The main objective of the proposed research is to determine the utility of the remote laser fluorescence/fiber optics ground-water contaminant detector (RFD) technique for monitoring biodegradation processes in ground-water systems. Secondary objectives include the determination of parameters important in regulating biodegradation in aquifers, and a demonstration of such regulation in an artificial aquifer. A natural extension of this work will be to field test this new technique at existing sites where biodegradation of ground-water pollutants is occurring, but such testing is beyond the scope of the proposed work.

4. Approach. The study of ground-water contaminant biodegradation processes as proposed here has only recently become possible with the invention of the RFD method. Only with such a real-time analysis method can the parameters important in regulating biodegradation be carefully evaluated, and the immediate adjustments needed for process control be accomplished. By using an artificial aquifer in the laboratory, conditions important to biodegradation can be carefully controlled and manipulated, and the results of such changes can be rapidly assessed using the RFD method.

5. Result users. The results of the proposed research will be of use to workers solving the problems associated with initiating and controlling biodegradation processes at existing disposal or hazardous waste sites. It will provide a new, effective ground-water management procedure to the engineering community.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1304
PROJECT TITLE:	Soil-Phase Photodegradation of Toxic Organics at Contaminated Disposal Sites for Soil Renovation and Ground Water Quality Protection
PERFORMING ORGANIZATION:	Utah State University Logan, UT 84322-0300
PRINCIPAL INVESTIGATORS:	William M. Moore Joan E. McLean
DATES:	September 22, 1986, through September 21, 1988

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. The release of refractory, nonbiodegradable, hazardous organics to the terrestrial environment via industrial waste discharges and waste-disposal practices has severely impacted land and water resources in many industrialized areas of the country. Photochemical reactions induced by direct light energy adsorption by contaminants (direct photolysis), or by light energy transfer from energy adsorbing/transferring substances (sensitized photolysis) provide potential pathways for the removal of many of these complex organics, i.e., polynuclear aromatic hydrocarbons (PAHs), phenols, aromatics, substituted and chlorinated aromatics, etc., from solution and soil phases. These photochemical reactions have been shown to be quite effective for a number of pesticides and PAHs, and may prove technically and economically attractive as a treatment approach for renovation of contaminated soil systems for soil detoxification and ground-water contamination prevention.

This project will investigate the quantitative nature of contaminant soil phase direct and sensitized photolysis on a range of actual soil media in laboratory-scale photolysis experiments simulating natural sunlight conditions, and will investigate the possibility for optimization of observed photodegradation reactions through various engineering management techniques.

2. Contribution to problem solution. The proposed research will provide information allowing the determination of the applicability and effectiveness of soil-phase photolysis as a degradation pathway for a number of refractory hazardous organics of environmental concern. Results will provide a methodology for the evaluation and prediction of the nature and extent of soil-phase photodegradation of environmental and engineering significance.

3. Objectives. The specific objectives of the proposed research are to:

   a. Develop a quantitative description of photochemical reactions as a function of reaction conditions (sensitizer type and concentration, substrate concentration, soil type) for selected PAH, aromatic and substituted aromatic compounds and their mixtures.

   b. Investigate photochemical intermediates occurring from the photodegradation of these parent compounds.

   c. Investigate the photolysis of a complex waste modeled by the compound mixture used above to provide insight into competing reactions that might be expected in actual field applications.

   d. To identify management options available for the control and optimization of photodegradation reactions for constituent/overall waste hazard reduction.

4. Approach. Soil-phase photolysis experiments will be conducted with contaminant application to thin soil layers under controlled light conditions. An evaluation will be made of soil-phase photolysis rates and pathways as a function of soil type and soil-phase photolysis reaction. Actual wastes containing pure constituents of interest will be photolyzed to reflect quenching or sensitization of photochemical reactions that may not be predicted from pure compound mixture experiments.

5. Result users. Results will be directly usable by the U.S. Geological Survey, the U.S. Environmental Protection Agency, and State and local health and environmental pollution control professionals, as well as by private companies and individuals, for the evaluation of the importance of contaminant soil-phase photodegradation for hazard-potential assessment and soil and aquifer remediation analysis.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1305
PROJECT TITLE:	Solute Segregation During Soil Freezing and Solute and Heat Transport in Permafrost
PERFORMING ORGANIZATION:	University of Alaska Fairbanks, AK 99775-0800
PRINCIPAL INVESTIGATORS:	J. P. Gosink Thomas E. Osterkamp
DATES:	September 15, 1986, through September 14, 1989

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. This is a research project on solute segregation during soil freezing and on water transport in frozen soils and permafrost. The emphasis of this research will be on theoretical aspects and modeling.

2. Contribution to problem solution. This proposal complements experimental field and laboratory research, funded by NSF and the State of Alaska, presently underway at the University of Alaska.

3. Objectives. The primary objectives are to develop an understanding of the physics of solute-segregation processes during soil freezing and of solute and water transport processes in frozen soils and permafrost. This information is necessary to properly assess a wide range of environmental, engineering, and geophysical problems involving the transport and fate of salts, gold and other metals, insecticides, herbicides, fertilizers, nutrients, mining wastes and waste waters in permafrost regions.

4. Approach. The research will focus on saturated coarse-grained soils (sands and coarse silts) using pore-water salt concentrations which are representative of problems associated with water resources. The physics of solute segregation in soils will be approached, initially, by attempting to extend the theory for solute segregation in crystals and in sea ice. The investigators will evaluate the potential physical mechanisms for salt and water transport in frozen soils and permafrost and incorporate these into the numerical models. Modeling efforts will make use of existing finite-element models for phase change in saturated freezing soils. Extension of these models to soils containing salts will be attempted by including the effects of salt segregation, salt redistribution and freezing-point depression.

5. Result users. Results can be used by any organization or agency concerned with permafrost problems.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1308
PROJECT TITLE:	Ground-Water Investigation of Sulfate Diffusion from a Cretaceous Shale Hillslope: Upper Colorado River
PERFORMING ORGANIZATION:	Utah State University Logan, UT 84322-8200
PRINCIPAL INVESTIGATOR:	Christopher J. Duffy
DATES:	September 1, 1986, through August 31, 1988

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. It is generally recognized that shallow ground water and saline marine shales play an important role in the dissolved-solids discharge of streams crossing the interior region of the Upper Colorado River basin. However, the hydrology and transport processes driving this salt loading are largely unknown. The economic and cultural problems of large salt loads in the downstream reaches of the Colorado River are well documented.

2. Contribution to problem solution. This study is an attempt to examine the hypothesis that vertical diffusion of salts from low-permeability marine shales to overlying ground water on alluvium-covered slopes may play a significant role in this process.

3. Objectives. A field study will examine the feasibility of diffusive transport of sulfate salts from Cretaceous shales underlying a hillslope in the Price River Basin, a subbasin of the Colorado.

4. Approach. The relative roles of advective displacement and diffusive weathering of sulfate salts will be examined.

5. Result users. The impact of these transport mechanisms on dissolved-solids discharge relations in the Upper Colorado Basin will be explored. Once the physical model has been calibrated and verified, it will be used to evaluate the various management alternatives for reducing the salt load to a receiving stream by (1) canal lining, (2) improved irrigation efficiency, and (3) the retirement of agricultural lands from irrigation.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1311
PROJECT TITLE:	Geostatistical Interpolation of Hydrostratigraphy at Ground-Water Contamination Sites
PERFORMING ORGANIZATION:	University of California at Santa Cruz Santa Cruz, CA 95064
PRINCIPAL INVESTIGATOR:	Shirley J. Dreiss
DATES:	September 30, 1986, through September 29, 1988

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. Directions and rates of contaminant movement are largely determined by the three-dimensional geometry and spatial variability of aquifer materials. Recent studies have demonstrated that geostatistics provides a quantitative means for describing the spatial continuity of aquifer hydraulic properties such as hydraulic conductivity and transmissivity.

2. Contribution to problem solution. Construction of three-dimensional variogram models requires extensive quantitative measurements that are not feasible at many contamination sites. Thus a need exists for a method to quantitatively interpret hydrostratigraphy at ground-water contamination sites using readily available data.

3. Objectives. The objective of this proposal is to investigate the usefulness of geostatistics, specifically an indicator-function approach, for interpreting complex alluvial stratigraphy from qualitative borehole logs. These logs provide an extensive data base of lithologic descriptions. This study will use existing logs from several contamination sites in Santa Clara Valley, California. We propose to quantify borehole logs with a binary indicator function chosen on the basis of inferred high- and low-permeability zonation. We will then develop experimental variograms and construct variogram models to describe the structure and spatial continuity of several depositional environments, including alluvial fan, outer fan, and interfluvial basin environments.

4. Approach. Kriging of the indicator variograms will generate a least-square, three-dimensional interpolation of the likelihood that any point in space is composed of either high- or low-permeability material. Aquifer-aquitard maps and cross sections will be constructed that depict estimated hydrogeologic boundaries for a specified minimum probability of high- (or low-) permeability occurrence. These maps will define boundaries with associated uncertainties that can be used in ground-water flow and contaminant transport models. In addition, regions where the hydrostratigraphy is poorly defined can be identified and used as a guide in site investigations to locate future boreholes.

5. Result users. If this approach is successful, it will be applicable to investigations at numerous ground-water contamination sites in sedimentary geologic materials.

SURFACE-WATER MANAGEMENT

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1285
PROJECT TITLE:	Improved Methods for Regional Flood-Frequency Analysis
PERFORMING ORGANIZATION:	Colorado State University Fort Collins, CO 80523
PRINCIPAL INVESTIGATOR:	Jose D. Salas
DATES:	September 30, 1986, through September 29, 1989

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. The prediction of extreme hydrologic events such as floods is of major importance in the planning and design of water-resources projects, but prediction is limited by the data available at a given site and by the underlying mechanism generating such flood events. When data is not available at a given site, one approach to flood prediction is regional frequency analysis. The research proposed addresses specifically the prediction of flood events on a regional context.

2. Contribution to problem solution. An important factor in any flood-frequency analysis is the assumption of the parent distribution, especially in such areas where different hydrometeorological mechanisms (for instance snowmelt and rainfall) may be responsible for extreme flood events. Likewise, an appropriate modeling and estimation procedure is another relevant factor for flood prediction. This research intends to better model the flood parent distributions and to improve the estimation procedures commonly available for regional flood-frequency analysis. It is expected that this research will improve the accuracy of flood prediction at ungaged watersheds.

3. Objectives. The specific objectives of the research are:

   a. To review the existing parent probability distributions and to develop new parent distributions suitable for modeling regional floods generated by a mixture of two or more regimes.

   b. To develop and test improved regional flood-estimation techniques using: (1) a more convenient at-site parameterization; (2) maximum-likelihood estimation of the regional parameters; and (3) a methodology for incorporating spatial dependence among annual floods.

c. To apply the concepts developed in (a) and (b) to two regions: (1) a region in Colorado with sufficient flood records affected by both snowmelt and rainfall; and (2) a region in southeastern U.S. which is affected by regimes of tropical storms or hurricanes and thunderstorms.

4. Approach. Existing hydrologic and statistical literature will be critically reviewed and a number of mixture models will be developed and tested based on the data selected for the two case studies. A major emphasis will be on developing parsimonious mixtures and their relationship to physiographic and climatic characteristics. The application of techniques of maximum likelihood for estimating the regional parameters and the development of simpler methods for incorporating the spatial dependence among annual floods in the region will be carried out. A hierarchical regional estimation procedure will be followed in order to come up with parsimonious models. Comparison of various models will be based on a number of statistical techniques including the Akaike information criteria.

5. Result users. The major results will be published in a project report and in a number of papers to be submitted for publication in technical and scientific journals. The results will be useful for Federal, state, and local agencies interested in water-related problems in general and flood-related problems in particular.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1291
PROJECT TITLE:	A Method for the Radar-Based Short-Term Prediction of Flood-Causing Rainfall Over a Watershed
PERFORMING ORGANIZATION:	University of California at Davis Davis, CA 95616
PRINCIPAL INVESTIGATOR:	M. Levent Kavvas
DATES:	September 30, 1986, through September 29, 1989

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. According to a study performed by the J.H. Wiggins Company (1978) for the National Science Foundation, riverine flood was found to be America's most devastating natural hazard. In a typical year (1978), floods destroy or damage approximately 410,000 buildings across the nation and incur a damage cost of 3 billion dollars. Most of the damage by riverine flood is due to lack of preparedness. Usually the community on a flooded small-to-medium sized watershed (area$\leq$1000km^2) is caught offguard and has little or no protective preparation against the flood. Flood losses can be minimized by short-term prediction of the arrival of potentially flash-flood-causing rain fields onto these small-to-medium sized watersheds several hours in advance of their arrivals. These advance warnings could provide time for the community to take protective measures and to evacuate the region.

2. Contribution to problem solution. The detection of a rain field on a fine time-space grid several hours in advance of its arrival at a small to medium-sized watershed, the extrapolation of this field to the watershed, and ground rainfall estimation comprise the basic components of a short-term rainfall forecasting scheme which is used within a flash-flood warning system. The detection of a rain field is performed best by a weather radar. The radar observation would envelop the field's spatial configuration, orientation, and the rainfall intensity distribution. Furthermore, as the rain field enters the radar's scope, the field's initial location, initial speed and initial direction are also observed. The second component of the rainfall prediction is the extrapolation of the detected rain field onto the watershed in interest in time and space. The final component is the estimation of the ground rainfall.

3. Objectives. The overall objective of this project is to develop a radar-based statistical scheme for the short-term prediction of potentially flash-flood producing rainfall events in time and space on small-to-medium sized watersheds ($\leq$ 1000km2).

4. Approach. This scheme will be based on:

a. The development of a statistical procedure to extrapolate in time and space rain fields detected on a radar scope onto a watershed located within the radar scope.

b. The development of a statistical procedure for the estimation of radar calibration factors as a function of both time and space in order to estimate the ground rainfall from the extrapolated rain field.

c. Testing the performance of the statistical procedures by means of the historical radar-raingage data on selected medium- to small-sized watersheds across the United States.

5. Result users. The purposed research would be a valuable flash-flood warning tool for all municipalities. A potentially flood-producing rain event which is predicted several hours in advance of its arrival by the proposed scheme, can be input into a hydrological model to forecast the potential riverine flood . Once flooded areas are determined, flood warnings can be issued. The proposed research will provide significant advances in the area of short-term statistical prediction of the evolution of radar-detected rain fields in space and time since little research has been done in this vital component of flood prediction.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1293
PROJECT TITLE:	The Effects of Nutrients and Pesticides Applied to Suburban Grassed Areas on the Quality of Runoff and Percolated Water
PERFORMING ORGANIZATION:	Pennsylvania State University University Park, PA 16802
PRINCIPAL INVESTIGATORS:	Thomas L. Watschke Ralph O. Mumma
DATES:	September 1, 1986, through August 31, 1988

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. The effect of nutrients and pesticides applied to lawns on the quality of runoff and percolated water is not well documented. Despite this fact, in the March 18, 1985, issue of U.S. News and World Report, Senator Dave Durenberger (R-Minnesota) of the National Water Alliance stated, "When you combine poor soil conservation with the new fertilizers everybody puts on their lawns, you have real problems. The fertilizers and pesticides run into the streets, then into the storm sewers and from there into the drinking-water intakes and our rivers."

2. Contribution to problem solution. Most of the available information concerning urban-suburban watersheds is limited to the quality of water coming from impervious surfaces. Studies indicate that water quality tends to decline as urbanization increases due to the movement of undesirable materials in runoff from impervious surfaces such as roads, sidewalks, and parking lots. Little is known about the quality of runoff from pervious surfaces (grassed areas) in urban-suburban watersheds.

3. Objectives. With the dramatic increase of nutrient and pesticide use that is primarily the result of growth in the professional lawn-care industry, the quality of runoff and percolating water has been adversely affected. By monitoring the quality of water emanating from and moving through experimental grassed sites, the magnitude of the problem can be determined and appropriate management strategies adopted.

4. Approach. A water-quality research site has been developed at Pennsylvania State University to assess the quality of water emanating from grassed areas. The site has twelve sloping plots, each with an automatic irrigation system and an automated collection system at the bottom of the slope. Four lysimeters per plot will be sampled for pesticide and nutrient movement below the grass root zone. Pesticides will be applied in accordance with label recommendations and samples for water-quality analyses will be taken at pre-determined intervals during every runoff occurrence. Samples will be analyzed and data can be compared to current Public Drinking Water Standards.

5. Result users. This research will provide documentation for developing guidelines to reduce or eliminate management practices that are found to cause undesirable water-quality effects. Results could also be utilized to help formulate water-quality standards for storm-water runoff from urban-suburban watersheds. Sewer and water authorities would have hard evidence as to whether management inputs to the landscape decrease the quality of water they utilize or treat.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1300
PROJECT TITLE:	Mitigation of Hydrologic Effects of Urbanization
PERFORMING ORGANIZATION:	University of Washington Seattle, WA 98195
PRINCIPAL INVESTIGATORS:	Stephen J. Burges Dennis P. Lettenmaier
DATES:	September 30, 1986, through September 29, 1988

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. The major problem area addressed by this proposal is mitigation of the effects of urbanization on hydrologic runoff response, as evidenced directly by changes in flood and dry-weather flows, and indirectly by channel and water-quality degradation. The solution approach proposed is based on the development of subcatchment-level runoff-production maps, and an accompanying hydrologic-hazard index. The proposed work differs significantly from earlier work in that the proposed methods are hydrologically, rather than hydraulically, based.

2. Contribution to problem solution. The key contribution of this work is that the proposed hydrologic characterization methods, and the similarity measures on which post-development mitigation measures would be based, will have a sound physical hydrologic basis. The procedures to be developed will permit explicit recognition of the location of dominant runoff-production areas (Hortonian and saturated overland flow) as well as locations from which predevelopment storm runoff is minimal. The runoff-production mapping methods to be developed in the proposed research will facilitate the allocation of resources to mitigative measures in a cost-effective and hydrologically sensible manner.

3. Objectives. The objectives of the proposed research are:

   a. To develop a method for characterizing the predevelopment hydrology of an urbanizing catchment.

   b. To develop criteria for post-development runoff control that represent a range of flood and dry-weather runoff conditions.

   c. To develop a method for identifying strategies for post-development runoff mitigation, based on the predevelopment hydrologic criteria.

4. Approach. The proposed approach will address the problem of hydrologic characterization at two levels: subcatchment (10-50 acres) and catchment (0.5-2 mi^2). The measures to be used at the subcatchment-level will emphasize field and topographic measurements, soil conditions, vegetation type and density, and hypsometry, as well as channel geomorphic properties. These properties will form the basis for dry-weather and flood-runoff indices at the subcatchment level. At the catchment level, measured hydrologic properties, such as (partial duration) flood-frequency estimates for peak flow rates and volumes, flow duration curves, and an estimator of the dominant flow will be used. The end result will be runoff-production zone maps, and an associated hydrologic-hazard index, at the subcatchment level, which will be aggregated to assure consistency with catchment-level measured hydrologic properties. Runoff-mitigation strategies consistent with the identified runoff-production zones will be developed to insure similarity of pre- and post-development catchment hydrology.

5. Result users. The results of the proposed work will be of direct use to stormwater management agencies, such as city and county public works departments, and stormwater management utilities, as well as to planners at regional and state levels.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1310
PROJECT TITLE:	Control of Blue-Green Algal By-Products in Drinking Water from Lake Thunderbird
PERFORMING ORGANIZATION:	University of Oklahoma Norman, OK 73019
PRINCIPAL INVESTIGATOR:	Paul T. Bowen
DATES:	September 30, 1986, through September 29, 1987

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. The presence of freshwater algae in reservoirs and impoundments can impair the quality of waters used for public water supplies. Algae are known to cause taste and odor problems in many water supplies. However, a more serious problem is posed by several species of blue-green algae which produce exotoxins. While human deaths have not been reported, outbreaks of gastroenteritis have been associated with these toxins. This project will focus on two aspects of this problem. First, a study of the lake habitat of toxin-producing algae will be conducted. An effort will be made to determine environmental conditions leading to toxin production. The second aspect will be removal of algal toxins from water supplies at the treatment plant. Conventional water-treatment methods, as well as adsorption and oxidation will be investigated.

2. Contribution to problem solution. Results of the proposed project can be used to formulate solutions to the algae problem. Data from the lake study will be instrumental in predicting if an algal bloom will become toxic or if environmental conditions in the lake are suitable for algal growth. These predictions would allow the use of another water source if problems were foreseen. The treatment study will determine how a water-treatment system can be designed to remove algal toxins, thus allowing continued use of an impaired water supply.

3. Objectives. The main objectives of this project are to develop a better understanding of (1) the relationship between reservoir environment and blue-green algae capable of producing toxins and (2) processes to remove algal toxins from drinking-water supplies. Meeting these goals will allow control schemes for toxic algal by-products to be developed and implemented.

4. Approach. This project will be conducted in several phases, incorporating field work, laboratory experiments, and statistical analysis. Phase I will consist of preparing the analytical instrumentation to detect and quantify algal toxins. A field study of Lake Thunderbird will be Phase II. Water samples will be collected and returned to the laboratory for analysis. Assessment of conventional and innovative treatment processes will be conducted in Phase III. Pilot- and bench-scale units will be used to measure algal toxin removal efficiency of treatment processes. Phase IV will be a statistical analysis of data collected during each phase.

5. Result users. The results of this study will be important to several levels of users. Municipalities which draw their drinking water from reservoirs and impoundments will be interested in the project results. State health departments will find these results helpful in answering questions and providing guidance to local governments. The Federal government can use these results in establishing defined treatment processes and determining water-quality standards.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1319
PROJECT TITLE:	Alluvial-River Bed Transport Process with Graded Material
PERFORMING ORGANIZATION:	University of California at Berkeley Berkeley, CA 94720
PRINCIPAL INVESTIGATOR:	Hsieh W. Shen
DATES:	September 30, 1986, through September 29, 1989

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. The proposed study addresses several aspects of the hydrologic cycle: erosion, sediment transport and alluvial-river stability. Most research studies on bedload transport in the laboratories have been conducted for uniform sediment sizes, yet most watersheds and streams carry nonuniform sediment sizes. This project will conduct a basic comprehensive analysis of the transport of cohesionless bedload with nonuniform sediment sizes using a combination of physical and numerical models.

2. Contribution to problem solution. Results from this study will contribute to the solution of the following problems:

   a. Amounts of sediment yielded from watersheds;

   b. Stability of alluvial channels--through better understanding of bed movements;

   c. Degradation from reservoirs--through better understanding of bed armoring;

   d. Hydraulic conditions for enhancing fisheries in gravel-bed streams through better understanding of the deposition and erosion of fine sediments on gravel beds.

3. Objectives:

   a. To determine, for fixed sediment particles on channel beds, the relationship between the actual forces (time series) on the sediment particles (both uniform and nonuniform size distributions) and flow characteristics through physical experiments. Particular attention will be placed on the sheltering effects of large particles on smaller particles;

b. To examine and analyze the bedload movements on nonuniform sediment size particles from physical experiments;

c. To develop a mathematical model or models for describing bed armoring processes;

d. To develop a mathematical model or models for describing bedload transport for nonuniform sediment sizes.

4. Approach. The first step is to measure the time fluctuation of both drag and lift forces on a sediment particle surrounded by sediment particles of the same size. The second step is to determine the shelter effects of large sediment particles on smaller sediment particles through flow and force measurements. A great number of experiments will be made with movable sediment particles. Different sediment layers will be examined. Based on a combination of probabilistic approaches and "modified hiding factors," certain mathematical models will be constructed. The "hiding factor" must be a function of flow because the effects of larger sediment particles on smaller particles must be different for different flow conditions. For low transport rates, the larger sediment particles will not be moved by the flood and will shelter movements of smaller particles. For very high transport rates, larger sediment particles may even "push" the smaller sediment particles. This proposed study is an attempt to collect more pertinent data and to conduct a comprehensive analysis.

5. Result users. Engineers, planners, geologists, hydrologists, and researchers.

SYSTEMS OPERATION, PLANNING

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1297
PROJECT TITLE:	Optimal Real-Time Forecasting and Control of Reservoir Hydrosystems Using Remote and Onsite Sensors
PERFORMING ORGANIZATION:	University of Iowa Iowa City, IA 52242
PRINCIPAL INVESTIGATORS:	Konstantine P. Georgakakos Aristidis P. Georgakakos
DATES:	September 1, 1986, through August 31, 1988

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. The proposed research project addresses the development and testing of integrated methodologies for the optimal real-time operation of reservoir systems in order to contribute to solutions of problems relating to flood control, irrigation, and municipal water supply and hydropower production. Methodologies to be developed and tested will be adapted to microcomputer implementation for real-time use at the control sites of reservoir systems. The proposed project will be the first one to couple in real time all the modern-day operational hydrometeorological data with operational models pertinent to the optimal utilization and control of reservoir inflow systems (rain and ground waters).

2. Contribution to problem solution. The research project will integrate physically based, real-time hydrometeorological forecast models with optimal real-time reservoir control models. In order to arrive at maximally efficient utilization and optimal real-time control of the reservoir system inflowing waters.

3. Objectives. Objectives of the research will be to make contributions to the following:

a. Operational management of multi-purpose reservoir systems;

b. Optimal design of multi-purpose reservoir systems;

c. Identification of the elements of the hydrologic cycle that are most important in the real time decisionmaking concerning utilization and control of rain and ground waters;

d. Assessment of the usefulness in real-time hydrometeorological prediction and control problems of operationally available data from remote and onsite sensors;

e. Feasibility studies as to whether integrated real-time prediction and control of reservoir hydrosystems are suitable for micro-computer implementation.

4. Approach. It is proposed to solve the real-time prediction and control problem by using: 1) real-time information from remote and onsite sensors, such as radar, satellites, raingages and river-stage gages; 2) physically-based hydrometeorological models of rainfall and riverflow processes; and 3) modern estimation and control-theory techniques that will quantify the uncertainties in the operating real-world reservoir systems, and that will solve the inference problems arising from the interface of model predictions and observational data. These techniques will be used to address problems of flood control, irrigation and municipal water supply, and hydropower production. Methodologies to be developed and tested will be adapted to microcomputer implementation for real-time use at the control sites of reservoir systems.

5. Result users. Agencies which will benefit from the results of the proposed research effort include: (1) those agencies responsible for the operational management of reservoir hydrosystems: flood-control district agencies; Corps of Engineers; (2) agencies responsible for water data collection and management: U.S. National Weather Service; U.S. Geological Survey; and (3) agencies responsible for flood forecasts: U.S. National Weather Service.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1318
PROJECT TITLE:	Stochastic Design of Waste-Water Storage for Land Application
PERFORMING ORGANIZATION:	University of Texas at Austin Austin, TX 78758-4497
PRINCIPAL INVESTIGATOR:	David R. Maidment
DATES:	September 1, 1986, through August 31, 1988

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. Land-application waste-water treatment systems include: (1) irrigation plots, (2) complete retention (evaporation) ponds, (3) runoff systems, and (4) high-rate infiltration galleries. The performance of irrigation plots and evaporation ponds depends on the stochastic properties of net potential evapotranspiration (NPET). When conditions suppress NPET, temporary onsite storage of waste water is needed. Most current methods to estimate waste-water storage requirements use a combination "rate and mass balance" approach to find the surface area and depth, respectively, of the storage facility. This approach is flawed because it does not consider: (1) the joint distribution or autocorrelation of inflows and outflows nor (2) project duration or carryover storage. Consequently, conventional methods provide no explicit estimate of storage reliability.

2. Contribution to problem solution. Performance of a land-application waste-water storage system is driven by the variability of NPET. At the University of Texas at Austin, the investigators have studied how the stochastic properties of NPET affect the reliability of storage facilities in humid and arid climates. They will apply their findings to develop improved methods for sizing waste-water storage ponds.

3. Objectives. Objectives are (1) to demonstrate that stochastic properties of NPET govern the performance of waste-water storage ponds at land-application sites and (2) to apply methods from stochastic reservoir theory to develop reliability-based procedures for sizing waste-water storage facilities.

4. Approach. The approach is to obtain the cumulative distribution function (CDF) of waste-water storage for transient and equilibrium conditions. Storage levels are given by a stochastic difference equation developed from the continuity principle. For independent stationary net input, the CDF of storage at time t is a convolution integral of the probability densities of the net input and the storage at time t-1. Alternatively, if only the first two moments of the net input distribution govern storage fluctuations, the transition probability density for the storage levels can be represented with the Fokker-Planck diffusion equation. Solutions to the integral and differential formulations will be obtained with Monte Carlo techniques used to simulate the operation of various waste-water storage configurations subject to a range of net input conditions experienced at typical land-application sites. Results from the Monte Carlo experiments will be summarized on storage performance functions (SPF) which are analogues of traditional storage-yield-reliability curves used in reservoir studies. Results will be checked with case studies at three locations from diverse climatic regions of Texas.

5. Result users. Applications of this research include: (1) regulatory agencies charged with approving land-application plans can use the equilibrium SPF to assess the long-term performance reliability of proposed waste-water storage facilities, (2) land-application operators can use the transient SPF to obtain short-term forecasts for storage levels in existing facilities and thereby evaluate the near term risk of a storage crisis, and (3) designers of land-application systems can use the equilibrium SPF as an aid to size and compare the economics of alternative waste-water storage configurations.

IRRIGATION MANAGEMENT

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1280
PROJECT TITLE:	Canal Automation Providing On-Demand Water Deliveries for Efficient Irrigation
PERFORMING ORGANIZATION:	California Polytechnic State University San Luis Obispo, CA 93407
PRINCIPAL INVESTIGATOR:	Charles M. Burt
DATES:	September 1, 1986, through August 31, 1989

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. Inflexible and poorly controlled deliveries of water to the farm have been identified as major causes of (a) low on-farm irrigation efficiences, (b) wasted energy through excess pumping to compensate for lower irrigation efficiencies, and (c) ground-water pollution from the leaching of fertilizers through over irrigation. Irrigation districts supply the majority of water to farms in the western U.S. District water must be ordered well in advance of each delivery, and flow rates and duration of deliveries cannot be changed by the farmer. Water deliveries are therefore classified as "supplier oriented" because the users do not have control of water deliveries and cannot take water or shut it off when needed. In addition, even when flows are delivered to a farm, they can typically vary by 10-30 percent due to poor canal water-level control. This inflexibility and insufficient control of water delivery is the opposite of what is required by modern on-farm irrigation methods and irrigation scheduling technology. This project will develop and test canal-automation techniques which can be implemented on existing irrigation district canals to provide water "on demand" to farmers.

2. Contribution to problem solution. Current user-oriented automated strategies must be part of the original canal design. Retro-fit solutions only provide automated "supplier-oriented" rather than "user-oriented" water deliveries. This research explores a canal-automation technique which will enable existing irrigation districts to convert to flexible, "demand-oriented" operations.

3. Objectives. To improve the logic and transferrability of previous research work on canal automation for rapid-demand delivery on sloping canals; to construct a 215-meter long scale model; to "field test" the logic and control equipment on the scale-model canal; and to refine modular control units for placement in existing canal systems with a minimum of hydraulic modeling of those individual canals.

4. Approach. This research will refine previous research done by the principal investigator on control logic using computer simulations, and implement that logic on a model canal.

a. Reasonably fast and accurate computer programs to model canal automation simulations require large computer memories which have not been available at reasonable cost until recently.

b. Instrumented scale-model canals to "field test" the logic and instrumentation have not been available. Regular canals in irrigation districts cannot be used for such experiments because the number of tests which can be run is limited and early tests will invariably cause overtopping and extensive canal damage.

c. Accurate water-level measurement equipment necessary for the proposed canal automation method was unavailable or too expensive in the past.

5. Result users. Irrigation districts throughout the western U.S. need a control system for canals. With the increased public awareness of the need for proper water management, reduced fertilizer leaching, and improved power-load management, the irrigation districts will experience pressure to improve their systems. In California alone, an estimated 6 million acres of irrigated farmland are served by irrigation-district canals which need such a control system.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1283
PROJECT TITLE:	Development and Field Evaluation of a Catenary Trail-Tube System for Reducing Irrigation Water Losses
PERFORMING ORGANIZATION:	South Dakota State University Brookings, SD 57007
PRINCIPAL INVESTIGATOR:	Shu-Tung Chu
DATES:	September 30, 1986, through September 29, 1989

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. Competition for fresh water among agricultural, industrial, and municipal users is expected to intensify in the future. A 1981 American Society of Civil Engineers report showed that irrigated agriculture accounts for 81 percent of fresh water withdrawn for consumption in the United States. Water application losses constitute a significant portion of irrigation-water withdrawals. A reduction of application losses from evaporation, wind drift and surface runoff will modify the intensity of competition for water among users. For example, a 5 percent increase in water-application efficiency by irrigated agriculture will provide a 26 percent increase in water available for municipal and industrial uses.

Trail tubes are perforated polyflex tubes which are connected to a center-pivot machine and replace sprinklers. The trail-tube irrigation concept offers a method of irrigation that has the potential to minimize irrigation losses, maximize water-use efficiencies and minimize energy requirements. The trail-tube system applies water under the crop canopy and directly to the soil surface at a rate that matches the infiltration rate of the soil. The water losses due to evaporation, wind drift, and surface runoff are thereby significantly reduced.

2. Contribution to problem solution. Trail-tube irrigation is currently being studied by research personnel at South Dakota State University. There is a need to expand the preliminary work to a more general field situation.

3. Objectives. It is proposed that tests be conducted to evaluate the concept under field conditions and to obtain quantitative data for use in the development of design and management guidelines.

a. Develop a comprehensive hydraulics theory for catenary trail tubes.

b. Test the validity of the developed theory under laboratory conditions.

c. Conduct field tests of a trail-tube irrigation system to determine water-use efficiencies and optimum tube spacing.

d. Compare water-use efficiencies, crop yields and energy requirements of a trail-tube and a low-pressure sprinkler irrigation system.

e. Establish design guidelines for the construction and use of a trail-tube system.

4. Approach. This research initially uses a theoretical analysis of trail-tube system hydraulics with subsequent laboratory verification and field evaluation under actual farming conditions. Comprehensive field data sets will be collected for a trail-tube and a low-pressure sprinkler irrigation system to determine the economical and operational feasibility of trail-tube irrigation.

Trickle and low energy precision application (LEPA) are two types of irrigation systems that have been used to enhance irrigation water and energy-use efficiencies. Emitter clogging and high initial costs have been identified as two major weaknesses of trickle irrigation. A micro-dike tillage practice is needed to control surface runoff under the LEPA system. The trail-tube irrigation concept will minimize the plugging problem by using larger perforations than the trickle system and will manage water-runoff problems by using long tubes and by matching the water application rate with the soil infiltration rate.

5. Result users. The research results will be useful primarily to farmers and irrigation equipment industries. The results will also be of value to irrigation extension engineers for the design of trail-tube systems.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1317
PROJECT TITLE:	Development of Improved Water Application and Management Techniques for Moving Irrigation Systems
PERFORMING ORGANIZATION:	University of Nebraska at Lincoln Lincoln, NE 68583-0726
PRINCIPAL INVESTIGATOR:	James R. Gilley
DATES:	September 15, 1986, through September 14, 1989

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. As water availability problems become more severe in the High Plains and other irrigated regions, and as competition increases for the existing water supplies, it will be necessary to both design and manage irrigation systems more efficiently. This study is directed toward developing more efficient water-application procedures which improve irrigation application efficiency, water-use efficiency and reduce nitrate-nitrogen movement to groundwater aquifers.

2. Contribution to problem solution. The predominant sprinkler irrigation method in the region both now and in the future is the center-pivot system. This system offers unlimited possibilities for improved management with reduced energy consumption if improved design and management schemes can be incorporated into the system. The proposed research will use field studies to evaluate the use of ultra-low-pressure, high-frequency operation as a technique to improve the performance of center-pivot irrigation systems and reduce nitrate movement. Detailed modeling studies will be used to extend these results to other soil and climatic conditions. These management criteria will enable irrigators to better respond to reduced water availability and improve the opportunities for implementation of effective public policies to enhance water conservation.

3. Objectives. Specifically, the objectives are to:

   a. Develop and evaluate ultra-low-pressure, high-frequency water application methods as a technology to improve the water application efficiency of center-pivot irrigation systems.

   b. Evaluate high-frequency irrigation as a methodology to reduce the movement of nitrate-nitrogen to the ground-water aquifer.

4. Approach. A combination field experiment with computer simulation models will be used to accomplish these objectives. Because of relatively large evaporation losses, high-frequency water application has not proven successful under center-pivot systems. However, by placing the water application devices within the crop canopy near the soil surface, these losses will be minimized. Placing the water devices within the canopy greatly reduces the area of coverage and increases the water-application rate, especially at the distal ends of center-pivot systems. With high speeds of rotation (reduced application depths) and interrow tillage, this problem will be lessened. Thus, by combining ultra low-pressure devices within the crop canopy and high frequency, the benefits of trickle irrigation may be extended to center-pivot systems.

5. Result users. The results of the study will be used by both irrigators and water managers. Irrigators will be able to use the results to improve irrigation efficiency and irrigation scheduling and reduce water and nutrient demands. Water managers will have better information regarding the performance of these systems and can improve recommendations on water allocations and better predict farm-level responses to irrigation-demand management initiatives.

DESALINATION/REUSE

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1281
PROJECT TITLE:	Anti-fouling Surface Modification for Longer-Lived Membranes with Constant Fluxes and Selectivities: AFT II
PERFORMING ORGANIZATION:	Georgia Institute of Technology Atlanta, GA 30332-4020
PRINCIPAL INVESTIGATOR:	Lois M. Speaker
DATES:	September 15, 1986, through December 14, 1987

PROJECT DESCRIPTION

1. Identification of the water and water-related problems and problem-solution approach. Membranes used in renovation of impaired waters are rapidly fouled by colloidal and semi-colloidal materials, lowering the cost- and energy effectiveness of membrane treatments. Membrane lifetimes are shortened and membrane selectivities are often sharply reduced. A post-manufacture modification of membrane surfaces (Langmuir-Blodgett layering) is proposed that can be applied to any commercial membrane, preserving the original separation characteristics while preventing fouling.

2. Contribution to problem solution. Electrodialysis membrane surfaces can be readily modified by the irreversible attachment of oriented monomolecular films, satisfactorily minimizing polarization and fouling. It is proposed here to optimize this antifouling technology (AFT) for commercial reverse osmosis (RO) and ultrafiltration (UF) membranes, evaluating selected modifications in accelerated lifetime tests.

3. Objectives. The hypothesis that the useful lifetimes and intrinsic selectivities of RO and UF membranes can be extended by AFT will be tested.

4. Approach. Selected fluorinated amphiphilic materials will be attached to commercially available membranes as oriented monomolecular layers, and the effect on fouling propensities, fluxes, selectivities, and lifetimes will be determined. The well-known repulsive character of a fluorinated surface will be augmented by the remarkable cohesive strength and perfect orientation of the applied layers.

5. Result users. Approximately 20 percent of the world's desalted water is processed by RO plants from seawater, brackish water, and municipal wastes. Thus, improvements in the fouling characteristics of RO membranes (and of UF membranes, which are frequently used for pretreating raw feed streams) will find not only industrial and governmental users, but also the increasing number of individuals at risk because of the limited availability of purified water.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G-1286

PROJECT TITLE: Removal and Selective Recovery of Heavy-Metal Ions from Industrial Waste Waters

PERFORMING ORGANIZATION: New Mexico State University
Las Cruces, NM 88003

PRINCIPAL INVESTIGATOR: Dennis W. Darnall

DATES: September 1, 1986, through August 31, 1988

PROJECT DESCRIPTION

1. Identification of the water and water-related problems and problem-solution approach. Accumulation of toxic-metal ions in water supplies is a matter of increasingly grave concern. Primarily the undesirable by-products of mining and industrial activity, these ions can cause acute and chronic illnesses in humans and other animals. In an effort to limit further contamination tate and federal laws have been implemented, requiring industries to install expensive pollution-control systems. Development of efficient, widely applicable, low-cost methods for removal of heavy-metal ions from waters, deserves high priority. For a number of years the investigator has been working on a new sorption process for removing heavy-metal ions from water based upon the natural, very strong affinity of the cell walls of algae for heavy-metal ions. Algae cells have been immobilized in a silica gel polymer and this preparation has been used much as ion-exchange resins are used to remove heavy-metal ions from water. This project will investigate what appears to be distinct advantages of the immobilized algae system over other technology presently used for heavy-metal ion cleanup of waste waters.

2. Contribution to problem solution. The proposed research will investigate the most economical procedures for removing heavy-metal ions from industrial waters using immobilized algae.

3. Objectives. The specific objectives of the research will be to determine the conditions under which the algae system is most suited for waste-water cleanup.

4. Approach. While the investigator has examined a number of parameters that affect metal-ion binding to Chlorella vulgaris, the following are some specific items that remain to be determined. This project will: a) test the temperature dependence of metal-ion binding to algae, b) examine the effects of Ca^{+2} and Mg^{+2} on transition metal-binding to the algae, c) test the effects of culturing conditions on the metal-binding capacity of the resulting biomass, d) examine metallo-oxoanion binding to the algae, e) investigate the mechanism of binding of metal ions to the algal system, f) test the algal system for removal of metal ions from electroplating-plant waste waters.

5. Results users. The conclusions drawn from the proposed studies may be used by Federal, State and municipal governments in dealing with waters contaminated by heavy-metal ions. They may also be used by industrial and mining operations that are concerned with removal of heavy-metal ions from waste waters.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1289
PROJECT TITLE:	Colloidal-Fouling Elimination in Turbulent-Flow Reverse Osmosis Treatment of Impaired Waters
PERFORMING ORGANIZATION:	Massachusetts Institute of Technology Cambridge, MA 02139
PRINCIPAL INVESTIGATOR:	Ronald F. Probstein
DATES:	September 1, 1986, through August 31, 1989

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. One important factor limits the pressure-driven membrane process, reverse osmosis, from becoming a nearly "universal" means for producing fresh water from the treatment and reuse of impaired-quality waters such as waste waters, coal and nuclear power-supply waste waters, agricultural return flows and other saline or brackish waters. This factor is the formation of fouling films on the membrane from suspended and precipitated material in the water, resulting in flux decline and reduced system performance. It has recently been discovered that in laminar flow there exists a threshold membrane-permeation velocity below which no colloidal fouling or flux decline is observed so long as the colloid in the solution is stable. It is not known if the same phenomenon exists in turbulent flow. The proposed research centers on determining if there is a turbulent threshold velocity below which no fouling occurs or if there is a critical Reynolds number-fouling limit independent of permeation velocity.

2. Contribution to problem solution. It is hoped that the research will contribute to hydrodynamic and physical-chemical rules for designing and operating systems to prevent colloidal fouling at the membrane without at the same time significantly increasing capital costs associated with increased membrane area and colloid-stabilization equipment, or operating costs associated with chemical additions.

3. Objectives. To determine for stable colloid solutions in reverse osmosis systems if a threshold permeation velocity exists in turbulent flow below which no colloidal fouling or flux decline will occur, and to determine the optimum operating conditions to prevent colloidal fouling.

4. Approach. The approach will involve an extension of the theoretical model and experiments carried out to date. Ferric hydroxide fouling tests using cellulose-acetate membranes and saline and non-saline solutions will be run over a wide range of transitional and turbulent foulant concentrations, isobars, and isotherms to determine the existence of non-fouling behavior as a function of flow and permeation velocity. A second series of tests will be carried out, paralleling the first, using polystyrene latex spheres and a composite membrane.

5. Result users. The results of this research would be used by designers, manufacturers and operators of reverse osmosis systems for saline- and brackish-water conversion, and the treatment of impaired-quality waters such as coal and nuclear power-supply waste waters and agricultural return flow.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1295
PROJECT TITLE:	Mitochondrial Bioassay for Toxic Substances in Water
PERFORMING ORGANIZATION:	University of Wisconsin-Madison Madison, WI 53706
PRINCIPAL INVESTIGATOR:	John M. Harkin
DATES:	August 15, 1986, through August 14, 1989

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. This project addresses the problem of estimating the extent, nature, and severity of surface- and ground-water contamination by toxic pollutants. It concerns development of a simple, inexpensive bioassay for toxicants in water based on the phenomenon of reverse electron transfer (RET) in submitochondrial particles (SMP). Bioassays play a vital role in surveillance programs for toxic pollutants in water, but current biomonitoring methods are either too expensive and time-consuming or do not correlate well with established human and animal toxicity data. Tests based on the RET reaction in SMP are rapid and inexpensive and detect the aggregate toxicity of water pollutants; both theory and early experimental results indicate a response to all kinds of toxicants and suggest good correlation with known fish and mammalian toxicities.

2. Contribution to problem solution. The RET reaction in SMP discerns toxic pollutants in water quickly and inexpensively. Use of this bioassay would simplify biomonitoring procedures and allow expansion of water-quality monitoring programs with good assurance that toxicity assessments will correlate well with existing toxicity data bases.

3. Objectives. The project has two main objectives: a) to establish the RET test in SMP as the prime method for rapid screening of water samples for toxic pollutants; b) to conduct trials by monitoring selected surface- and ground-water samples subject to input of toxic pollutants.

4. Approach. Standard methods will be developed to assure production of stable SMP and reproducible execution of the RET test. Dose-response curves for a large number of toxicants will be determined and the results will be correlated with existing toxicity data bases. Procedures will be developed for applying the RET test to surface- and ground-water surveillance, e.g., biomonitoring of water samples from Lake Michigan basin surface- and ground-

waters subject to input of industrial pollutants, waste-dump leachate or pesticides from agricultural practices. Premarketing strategies for the RET test will be explored.

5. Result users. An RET bioassay kit will be developed which could be distributed nationwide to environmental scientists. Simplicity and cost effectiveness of the bioassay will allow greatly expanded surveillance programs to monitor trends in water quality.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1301
PROJECT TITLE:	Water Purification and Waste Concentration by the Vacuum-Freezing Multiple-Phase Transformation Process and Its Eutectic Extension
PERFORMING ORGANIZATION:	Calyxes Research & Development Corp. Albuquerque, NM 87107
PRINCIPAL INVESTIGATORS:	Chen-Yen Cheng Yin-Fong Su
DATES:	September 15, 1986, through September 14, 1987

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. The proposed project will investigate the technical and economic feasibility of treating waste water, industrial solutions, agricultural return flows and other important saline or impaired-quality waters by the Vacuum Freezing Multiple Phase Transformation (VFMPT) Process alone or in combination with the Primary Refrigerant Eutectic Freezing (PREUF) Process to obtain good quality, usable water and attain a very high degree of concentration of solutes for producing useful products or for easy disposal.

2. Contribution to problem solution. The PREUF Process, a eutectic freezing process, is an extension of the VFMPT Process. In each of these processes, the necessary cooling is accomplished by a vacuum-freezing operation and the first low-pressure vapor formed is liquefied by multiple phase-transformation operations. A basic study of the component steps will be completed; various ways of conducting the component steps will be explored; and efficient ways of integrating the components into compact processing units will be investigated.

3. Objectives. In all vacuum-freezing processes, liquid feed is subjected to a vacuum-freezing operation to produce a first vapor and a mass of solvent crystals. The first vapor must then be liquefied with its heat of vaporization recovered for melting the crystals. In the VFMPT Process, the first vapor is liquefied by the multiple-phase transformation operations and the problems of previous processes have been avoided. A low-pressure water vapor, as low as 0.5 torr, can now be liquefied reliably and a very concentrated solution can be handled by the VFMPT Process. There are two versions of the VFMPT Process, respectively denoted as VFMPT-A Process and VFMPT-B Process. In the VFMPT-A Process, the ice-washing and ice-melting operations are conducted under vacuum; in the VFMPT-B Process, the ice-washing and ice-melting operations are conducted under near-ambient pressures. Research of the VFMPT Process so far indicates that it may well emerge as a successful commercial vacuum-freezing process.

4. Approach. The VFMPT Process alone can concentrate a solution only up to the eutectic composition. The PREUF Process is a modification of the revolutionary eutectic-freezing process first introduced by Professor A. J. Barduhn of Syracuse University. In the original eutectic-freezing process, denoted as the Secondary Refrigerant Eutectic Freezing (SREUF) Process, a secondary refrigerant, such as a Freon, is vaporized in a eutectic mixture to obtain the necessary cooling and form crystals of the solvent and solute. In the PREUF Process, the cooling needed is accomplished by vaporizing the volatile components from a eutectic mixture. The first vapor so formed is liquefied by multiple-phase transformation operations. Therefore, the use of a secondary refrigerant and its associated problems, refrigerant recovery and refrigerant loss, have been avoided. In the PREUF Process, the rate of vapor removal and thus the degree of supercooling is controlled by the heat-removal rate at the condenser. With good control of supercooling, relatively large crystals can be grown, making separation of crystals of different components easier. A combination of the VFMPT and the PREUF Processes may reduce waste waters and industrial waters to purified water and solid waste.

5. Result users. The results have potential applicability for the economic separation of water from concentrated saline or waste streams.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1307
PROJECT TITLE:	Waste-Water Purification by Solvent-Induced Precipitation Using Freeze Technology to Recover Solvent
PERFORMING ORGANIZATION:	CBI Industries, Inc. Plainfield, IL 60544-8929
PRINCIPAL INVESTIGATORS:	James H. Richardson David V. Benac
DATES:	September 19, 1986, through August 28, 1987

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. This proposal addresses the use of waters of impaired quality, especially those in the following categories: industrial process and rinse water, waste and disposal-pond waters, and cooling waters. CBI's innovative and proven indirect freeze process will effectively recover organic solvent for reinjection into a "solventing-out" operation. The organic solvent will be injected into waste waters with high inorganic impurity levels, causing precipitation of the contaminants and purifying the water.

2. Contribution to problem solution. Implementation of CBI's combined processes will result in: exceptionally high water recovery, more economical waste reduction, environmental improvement, and byproduct recovery.

3. Objectives. To determine the efficiency and effectiveness of treating various impaired-quality waters by using a "solventing-out" step for precipitation, and recovering the solvent via CBI's indirect freeze process.

4. Approach. CBI's preliminary investigations indicate "solventing-out" will dramatically lower the concentration of numerous dissolved salts. The disadvantage of "solventing-out" is the need to separate water and organic solvent. CBI's indirect freeze process easily separates the two liquids while avoiding the corrosion, hazards, and contamination encountered in evaporation.

5. Result users. CBI's research results could be used throughout this country by many manufacturers and processors. Also, the results would be especially helpful in the cleanup of hazardous waste ponds. This is a critical problem as more than two-thirds of our nation's landfills will close due to their inability to comply with recent EPA regulations. Successful research here would supply the means for compliance.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1313
PROJECT TITLE:	Efficiency of Carbon Utilization by *Thiobacillus Ferrooxidans*
PERFORMING ORGANIZATION:	University of Alaska Fairbanks, AK 99775-1760
PRINCIPAL INVESTIGATOR:	Edward J. Brown
DATES:	September 15, 1986, through September 14, 1989

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. The application of microbiological technology is being revitalized for leaching metals from metal-bearing ores, recovery of metals from wastes and desulfurization of coal. Microorganisms of the genus *Thiobacillus* (the iron-oxidizing autotroph, *T. ferrooxidans*, in particular) are essential to these microbiological processes.

2. Contribution to problem solution. The iron-limited growth kinetics of *T. ferrooxidans* and the mechanisms of iron oxidation have been studied. However, the nature of autotrophy in these microorganisms under varying conditions and its relationship to optimization of iron oxidation have not been studied.

3. Objectives. There is mounting evidence that many autotrophic organisms may excrete large amounts of fixed organic carbon--particularly when the nutrient supply is unbalanced and regulatory mechanisms fail. Thus, predictions of potential water-quality problems and/or rates of useful microbial processes (coal cleaning; biohydrometallurgy) based on models that assume balanced growth could be misleading.

4. Approach. It is proposed to use continuous cultures to study the specific activity of ribulose 1,5-biphosphate carboxylase-oxygenase in iron-limited *T. ferrooxidans* cultures when carbon dioxide, oxygen, ferrous iron, and ferric iron concentrations in the reactor vessel are varied. The results of these physiological studies should indicate growth requirements or optimum conditions to enhance (or prevent) microbial iron, sulfur and other metal oxidations.

5. Result users. Such results would be useful to the mining industries concerned with prevention of acid and heavy metal drainage to ground waters and surface waters and to industry concerned with metal recovery and coal desulfurization. State and Federal regulatory agencies would also use the results to help set guidelines for permit requirements.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1315
PROJECT TITLE:	Selective Removal of Trace Organics Using Surface-Grafted Polymers
PERFORMING ORGANIZATION:	University of California at Los Angeles Los Angeles, CA 90024
PRINCIPAL INVESTIGATOR:	Yoram Cohen
DATES:	September 1, 1986, through August 31, 1988

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. In recent years there has been mounting evidence that persistent toxic synthetic organics have been finding their way from various sources, including hazardous-waste sites, into the drinking-water supplies of various local communities. The presence of toxic organics in drinking-water supplies presents an intolerable public health hazard and a loss of valuable local water resources. Presently, there is an urgent need to develop effective low-cost alternative purification processes for the selective removal of trace organics from contaminated water supplies.

2. Contribution to problem solution. Since many of the toxic organics are found in trace levels, their selective removal is costly. Current methods for the removal of trace-level toxic organics that are normally nonpolar or weakly anionic, rely on separation by activated-carbon adsorption. Such methods are often inadequate due to the expensive regeneration step which requires large amounts of solvent or steam, the low capacity of the resin for nonpolar organics, the loss of resin activity, and the lack of control in resin selectivity. Consequently, the use of activated-carbon separation processes on a small scale at local communities has not been cost effective for the selective removal of trace nonpolar and weakly anionic organics. Concomitantly, there is an urgent need to develop an effective low-cost alternative to present water-purification processes for the selective removal of trace organics from contaminated water supplies.

3. Objectives The objectives of the proposed project will be to evaluate novel high-capacity solid-polymer bonded resins for the removal of trace organics from contaminated waste water.

4. Approach. The new separation resins will consist of hydrophobic and hydrophilic polymers grafted onto solid supports for the removal of hydrophobic and weakly anionic organics with an easy regeneration step that requires only small amounts of inexpensive non-toxic solvents. Data for process scale-up will be obtained regarding adsorption isotherms, adsorption kinetics and resin regeneration.

5. Result users. The proposed study is the first step toward the development and demonstration of a separation process for implementation by Federal and local agencies that are obligated to resolve the problem of contaminated-water supplies. The process should also be usable by industries for the removal of trace organics from industrial waste water prior to discharge.

ECONOMIC/LEGAL/INSTITUTIONAL

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1288
PROJECT TITLE:	A Comparative Feasibility Study of the Privatization of Waste-Water Treatment Works
PERFORMING ORGANIZATION:	Auburn University Auburn, AL 36849-3501
PRINCIPAL INVESTIGATOR:	John G. Heilman
DATES:	September 16, 1986, through September 15, 1988

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. The proposed research addresses the solution of social, legal, and institutional problems inhibiting the use of impaired-quality water such as waste water. Many towns and cities in the United States have a problem meeting federal clean-water standards and providing a clean-water environment. The problem is one of obtaining reasonably priced financing for the expansion or improvement of waste-water treatment works (WTW's). The Environmental Protection Agency (EPA) 1984 Needs Survey estimates that over $100 billion will be required for WTW construction between now and the year 2000. The need for such funding is increasing because the EPA has reduced its grant support for WTW construction while tightening WTW effluent standards. Nationally there are some 16,000 publicly-owned treatment works. Of these about 3,700 are classified as majors, meaning they discharge more than one one million gallons daily, or serve over 10,000 persons. The current estimate is that 1,382 majors and 2,500 minors need additional construction to meet effluent standards.

The purposed research addresses an innovative soltion to the problem of WTW construction funding: privatization, meaning private financing, construction, and operation of waste-water treatment facilities. Federal tax law changes in 1981 and 1982 included tax incentives which made the financing of WTW construction attractive to private investors in some circumstances. A few dozen cities across the nation have seriously considered privatization, and two cities are currently completing privately financed WTW construction. The waste-water problem will remain: WTW's will have to be built and public funding will be insufficient.

2. Contribution to problem solution. Advocates of privatization in the engineering and finance communities assert that it offers a sound public-private sector partnership through which facilities can be financed, built, and operated to meet effluent standards at lower cost and more efficiently

than through government grants or self-financing by cities. The dynamics of privatization and the conditions under which these assertions are sound need systematic definition and evaluation. Legislators and administrators at many levels of government need information about the benefits and risks of privatization, the track record of private financing versus public financing, and the nature of the issues underlying any municipal decision about privatization and WTW expansion. The policy-making process at all levels will be served by systematic investigation of these issues. For instance, the results of an empirical analysis of capital-intensive privatization need to be a part of the policy process in the areas of proposed tax reform and the reauthorization of the Clean Water Act, both currently under review by the U.S. Congress.

3. Objectives. The proposed research intends to analyze the administrative, legal, economic, and political feasibility and impacts of WTW privatization. It will assess how privatization is working where it has been used, and address the risks, costs, and benefits of privatization at the local level as well as at the levels of State and National Government. The bottom line objective is to determine where, when, how, and to what extent WTW privatization provides a useful answer to the problem of meeting clean-water requirements.

4. Approach. The overall approach to this task will combine several methods common to policy analysis and evaluation. In-depth case studies will be made of the cities which have privatized, as well as cities which have used government grant funding and still others which have considered privatization and rejected it. The costs and benefits to cities of the different funding approaches will be examined. Interview and survey data will be collected from relevant publics including local citizens and public officials, financial and legal experts, engineering and construction company officers and project managers, and State and Federal Government officials. The costs and benefits to the U.S. Treasury of privatization and other WTW funding approaches under different assumptions about interest rates and tax laws will be modeled.

5. Result users. The results will help policy makers and administrators at all levels of government as well as professionals in the engineering and business communities to make better informed decisions about privatization as one means of financing improvements in waste-water treatment facilities.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1303
PROJECT TITLE:	Economic and Legal Analysis of Strategies for Managing Agricultural Pollution of Ground Water
PERFORMING ORGANIZATION:	Virginia Polytechnic Institute & State University Blacksburg, VA 24061
PRINCIPAL INVESTIGATORS:	Sandra S. Batie Randall A. Kramer
DATES:	September 16, 1986, through September 15, 1988

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. This study addresses the problem of designing and implementing effective, legal, and appropriate State and/or federal strategies for the management of ground-water quality. The specific analysis is focused on agricultural chemicals as sources of ground-water contaminants.

2. Contribution to problem solution. The research will contribute economic and legal analyses of some ground-water management strategies (e.g. liability laws regulation, insurance, taxes, conservation easements). Essentially the research is designed to answer questions most commonly asked by decision-makers as they struggle to design ground-water management policies.

3. Objectives. The objectives are:

   a. To design alternative State and/or federal strategies for the management of environmental risks associated with agricultural pollution of ground water.

   b. To estimate the first-round impacts on farm income, land and water uses, government revenues and pollution levels resulting from implementation of alternative management strategies in a case-study context.

   c. To determine the constitutional issues and legal nature of any proposed strategies for the management of ground-water quality.

4. Approach. The main methods for the economic analyses will be (a) selection of appropriate case-study areas and agricultural chemicals, (b) use of mathematical programming model which combines physical transport variables with economic variables, and (c) use of input-output models where appropriate to estimate distributional impacts. The legal analysis will involve both searching State experiences and identifying analogous precedents.

5. Result users. The main users of this research are expected to be State level officials (and to a lesser extent Federal officials) charged with managing ground-water quality.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1306
PROJECT TITLE:	Efficient Management of Multiple Water Sources Given a Range of Quality Levels and User Quality Requirements
PERFORMING ORGANIZATION:	University of Arizona Tucson, AZ 85721
PRINCIPAL INVESTIGATORS:	William E. Martin B. Colby Saliba
DATES:	September 1, 1986, through August 31, 1989

PROJECT DESCRIPTION

1. Identification of the water or water-related problem and problem-solution approach. Local, State and Federal management agencies struggle to balance competing demands of water users with different quality requirements and to conjunctively manage ground- and surface-water supplies of varying qualities in an effective manner. This research develops and evaluates management strategies for coordinating water demand with supplies having differing quality characteristics. Management strategies developed seek to improve economic efficiency--to put water of varying quality levels to its highest-value uses at the least cost to society. Management strategies to be evaluated include market exchange of water supplies among user groups, water-use regulations, and innovative pricing structures for water use, treatment and delivery. Water uses considered include municipal, industrial, recreational, and irrigated agriculture. Water sources considered include not only native ground and surface water, but also municipal effluent, artificially recharged water, agricultural return flows, and recycled industrial waters.

2. Contribution to problem solution. The proposed research will facilitate informed decisionmaking and consideration of alternative management approaches by water managers in regions with multiple sources of varying quality. The research develops pricing strategies that provide incentives for efficient use of water supplies with differing quality characteristics. More efficient management of existing water supplies can reduce the need for costly supply-development projects and expansion of waste-treatment facilities.

3. Objectives.

   a. Develop management strategies which provide incentives for efficient use and allocation of water sources of differing quality, particularly impaired-quality water.

b. Evaluate the benefits and costs of alternative management strategies in the case-study region.

c. Based on conclusions from the case-study region, develop management guidelines for regions with multiple water sources of varying quality.

d. Communicate research findings to water managers, the public, and the scientific community.

4. Approach. The research is unique among previous studies of water management and water quality in its focus on efficient management of water demand and supply from sources of varying quality. The project extends previous research on water institutions, pricing policies, and conjunctive management in order to address water-quality concerns.

5. Result users. The results would be used by water policymakers, managers, and planners in relevant Federal, State and local agencies, and as a basis for ongoing research by government, university and private sector institutions.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1314
PROJECT TITLE:	Institutional Factors Affecting Quality Control of Municipal Ground-Water Supply
PERFORMING ORGANIZATION:	University of Massachusetts Amherst, MA 01003
PRINCIPAL INVESTIGATOR:	Edward R. Kaynor
DATES:	September 15, 1986, through September 14, 1987

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem solution approach. The problem addressed by this proposed research is the inability of the existing institutional framework adequately to detect and alleviate problems of ground-water contamination in municipal drinking-water supply systems. The specific approach to solution of this problem will be to study and analyze instances of municipal ground-water contamination in the New England region selected as representative cases from which to generalize potential solutions to such problems elsewhere.

2. Contribution to problem solution. The proposed research is intended to specify the range of existing institutional problems. In general, the advantages and disadvantages of the present operative institutional "system" for solving ground-water contamination problems will be identified, and analysis of these is expected to make possible recommendations which would improve the institutional system generally.

3. Objectives. Research to date indicates that too much attention has been paid to the system of laws and regulations and how these are administered within the formal confines of mission-oriented agencies of government. A guiding hypothesis of this proposed research is that the institutional structure as it is intended to operate is not very relevant in the decision-making process on ground-water contamination; that such matters as the threat of legal action brought by aggrieved citizens and the recommendations of local consultants are more significant incentives leading to solution of ground-water contamination problems than are the apparently more pertinent factors in the institutional system, such as action of federal and state environmental agencies, promulgation of Primary Drinking Water Standards, and the like. This proposed project will test the hypothesis that significant influence on the decision-making process is exerted from the "bottom up" rather than from the "top down" in our society's approach to problems of municipal ground-water quality; that therefore, the search for economic, efficient, and effective solutions to the problem should begin at the local level.

4. Approach. This proposed project will cull from the existing documents a sample of ground-water contamination problem areas which represent the broadest range of problem types. It will then obtain from further documentary research and interviewing procedures, the detail needed to evaluate actions to solve the contamination problems in this sample of cases. By selecting cases from the entire New England region where the problem has been historically severe, applicability to other regions will be maximized.

5. Result users. Results will be utilizable not only by the responsible agencies overseeing the municipal water-supply problems of the cases studied and analyzed, but also by agencies with similar problems elsewhere. If results point toward a need for more attention to local constraints on decisionmaking and less on responsibility at higher levels of authority, the results could be applicable to the legislative, administrative, and judicial agencies of government at all levels.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1320
PROJECT TITLE:	Efficient and Equitable Solution of Indian Reserved Water Rights Conflict
PERFORMING ORGANIZATION:	University of Arizona Tucson, AZ 85721
PRINCIPAL INVESTIGATOR:	William B. Lord
DATES:	September 22, 1986, through September 21, 1988

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem solution approach. Allocation of reserved water rights to Indian tribes pursuant to the "practicably irrigable acreage (PIA)" standard now employed by the courts is likely to produce pronounced inefficiency of water use, inequity among Indian and non-Indian water users, and substantial costs to the federal taxpayer, while failing to meet the needs of the Indians. A more adequate standard is badly needed by legislators, water users, and the courts. Also needed are means for resolving specific water-use conflicts involving Indian reserved rights. The proposed project will employ historical and legal research to define a solution concept which meets Indian needs, avoids uncompensated sacrifices by non-Indian water users, and minimizes Federal costs. It will employ economic, anthropological, and systems research to develop a procedure for generating options for conflict resolution.

2. Contribution to problem solution. The proposed research will develop one or more conceptual bases to replace PIA as the standard for awarding Indian water rights. It will develop a procedure for providing information which can be used by the parties to a specific water-rights conflict to resolve that conflict by negotiation, thus avoiding costly and lengthy legal proceedings.

3. Objectives. The objectives of the research are to develop a conceptual basis for establishing Indian water rights, to develop an analytical procedure which will provide the information needed to resolve specific Indian rights conflicts, and to apply the proposed analytical procedure in one test case, that of the Gila River General Stream Adjudication in Arizona.

4. Approach. Historical and legal research will be used to identify possible conceptual bases for resolving Indian water-rights conflicts. Social goals of efficient water allocation and equity will be used to choose those concepts which best satisfy the needs of Indians while avoiding harm to non-Indian water users and minimizing costs to the Federal treasury. The basic methodological approach to conflict resolution will be that of metagame analysis, a technique for predicting those strategies which participants in a complex conflict situation characterized by both common and opposing interest will select to achieve the most favorable outcomes for them. It is a nonquantitative extension of the theory of games which imposes cognitive tasks of manageable proportions upon stakeholders and which is well-adapted to the use of uncertain and ambiguous information. Metagame analysis does not define the options which must be selected to form strategies, so that a combination of historical, legal, and economic analyses will be used to generate these options. Social-psychological techniques, supplemented by anthropological expertise, will be used to elicit preferences for specific outcomes from participants in the Gila River Adjudication. These preferences will be analyzed by means of metagame analysis in order to identify stable combinations of strategies, the basis for creating consensus.

5. Result users. Participants in water-rights conflicts, legislators who must pass new laws governing Indian water rights, and courts which must apply such laws will use the results of this research.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1404
PROJECT TITLE:	An Interactive Environmental-Impact and Economic Analysis of the Benefits of Potable Ground Water on Cape Cod
PERFORMING ORGANIZATION:	Woods Hole Oceanographic Institution Woods Hole, MA 02543
PRINCIPAL INVESTIGATORS:	Steven F. Edwards Andrew R. Solow
DATES:	September 30, 1986, through September 29, 1987

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. This project will determine the economic benefits of protecting potable ground water from nitrate contamination.

2. Contribution to problem solution. Cape Cod, Massachusetts, is selected as a case study because the U.S. Geological Survey and State agencies already have characterized the nitrate problem and because it typifies sewage-disposal problems in many regions of the United States.

3. Objectives. The project has four sequential objectives relative to determining the expected value of economic benefits of potable ground water on Cape Cod: (1) to develop a policy-relevant environmental-impact model of nitrate contamination in public wells; (2) to estimate the household demand for potable ground water; (3) to estimate the aggregate benefits of managing ground-water supplies; and (4) to contribute to the development of a ground-water management plan for Cape Cod.

4. Approach. The study is expected to advance the economic analysis of ground-water contamination. First, the environmental-impact model will use statistical procedures to quantify the relationship between residential growth and observed nitrate levels in public wells. Previous efforts to model this relationship using univariate methods do not consider the lag structure between growth and nitrate levels, or the potential hydrogeologic and climatic differences across wells in space and time. The multivariate, distributed lag model proposed for our research is a logical improvement that will more closely mimic human impacts, and, therefore, is more likely to succeed.

Second, studies of ground-water potability have been confined to health effects. Use of the contingent-valuation method will facilitate estimation of the total demand for potable ground water, including the value placed on use, the convenience of using tap water, health benefits, option value, and protection of the resource for future generations. An important feature of the benefit study will be the influence of the probability of nitrate contamination (i.e., supply uncertainty), and of the timing of expected contamination on demand (both will be predicted from the above environmental-impact model). This information will help identify the correct option demands for use in the benefit analysis.

Third, the aggregate benefits of potable ground water will be estimated for all of Cape Cod. The value of household benefits will be determined from the demand model and the probability of and the year of expected contamination which are predicted from the environmental impact model. These estimates will be aggregated across households after testing for possible sample-related biases. Present values will be estimated using standard discounting techniques.

Finally, the results of the study will be disseminated to resource managers in the State through meetings and a technical report.

5. Result users. The study will make the following contributions to resolving the nitrate contamination problem: (1) the ground-water model will allow managers to predict the probability and associated year of expected ground-water contamination for each public well if current land-use practices continue; and (2) the benefit analysis will give policymakers a clear and credible estimate of the total economic benefits of ground-water protection which can then be compared to the expected costs of water-management programs.

The Executive Director of the Cape Cod Planning and Economic Development Commission has expressed a great interest on behalf of his office and of the Department of Environmental Quality Engineering to use the results of this study when formulating a management plan for Cape Cod.

CLIMATE VARIABILITY

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1294
PROJECT TITLE:	Climate and Streamflow Variability Related to Surface-Water Supply in Western United States
PERFORMING ORGANIZATION:	Colorado State University Fort Collins, CO 80523
PRINCIPAL INVESTIGATORS:	Thomas B. McKee Nolan J. Doesken
DATES:	September 30, 1986, through September 29, 1989

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. Surface-water supplies in the Rocky Mountain west are a precious commodity continuously affecting and limiting economic growth and development in the region. Management of this natural resource is made difficult by its large and unpredictable year-to-year variability, which has been particularly extreme during the past 10 years. Planners and policymakers have additional fears concerning recent predictions that surface-water supplies in the region could be significantly reduced as a result of the confirmed increase in atmospheric carbon dioxide.

2. Contribution to problem solution. This research is aimed at these concerns through an effort to understand regional variations in terms of their relationship to larger-scale atmospheric phenomena.

3. Objectives. Available precipitation, temperature, snowpack, and streamflow data in selected river basins from Montana and Idaho to Arizona and New Mexico will be used in this investigation. Annual precipitation will be broken down into components based on elevation, geographic location, river basin area, precipitation mechanism, duration, and distribution. From this stratification, the components contributing most to surface-water supplies will be isolated.

4. Approach. The relative variability of each component will be analyzed and correlated, through snowpack and streamflow, to the observed variability in surface-water supplies. The spatial and temporal variations of each of these inputs to the hydrologic cycle will be related to aspects of the large-scale atmospheric circulation, especially those shown by current research to offer the greatest potential for predictability.

This research will identify the components of the annual precipitation contributing most to the variability of surface-water supplies. Knowledge of the distributioand variability of each component in a mountainous area will help in understanding the complex nature of the hydrologic cycle in the Rocky Mountain region. Relationships with large-scale atmospheric/oceanic circulation systems can eventually lead to developing skill in predicting anomalies in future surface-water supply in the region.

5. Result users.
All Federal, State, and local agencies with water-management responsibilities are interested in the progress and results of this research. Agencies currently involved in hydrometeorological data collection and short-term water supply forecasting, such as the National Weather Service, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, U.S. Geological Survey, and the Soil Conservation Service, have immediate use for the results. Researchers in other climate-fields will also benefit from this research.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G-1309

PROJECT TITLE: A Reconstruction of the Water-Balance Response to Climatic Variations in Western Lake Basins

PERFORMING ORGANIZATION: New Mexico State University
Las Cruces, NM 88003

PRINCIPAL INVESTIGATOR: Fred M. Phillips

DATES: September 1, 1986, through August 31, 1989

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. This proposal addresses the problem of climatic variability and the response of the hydrological cycle. We intend to approach this problem by reconstructing the water balance of closed-basin lakes in New Mexico and California based on isotopic and chemical characteristics of sediments in cores.

2. Contribution to problem solution. The proposed research will provide a record of water-balance fluctuations in the western United States of sufficient length that the causes may be analyzed and the possible range of fluctuations ascertained.

3. Objectives. To reconstruct the water balance in the western U.S. in sufficient detail, and over a sufficient length of time, in order to identify the causes of water-balance fluctuations.

4. Approach. We intend to collect data on carbonate mineralogy, trace elements in carbonate, and ^{18}O abundances in carbonate sediments out of long lacustrine cores from Searles Lake, California, and San Agustin Lake, New Mexico. Lake levels will be reconstructed using numerical modeling of the isotopic and chemical characteristics of the sediments. The lake-level fluctuations will be used to construct a record of the basin water balance. This water-balance reconstruction will be interpreted by means of time-series analysis and comparison with independent climatic records.

5. Result users. The results will be of immediate interest to climatologists, precipitation/runoff hydrologists, and watershed-management specialists. Ultimately, it is hoped that they will be of practical value to all water-resource planners in the western United States.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1312
PROJECT TITLE:	Late Quaternary Paleohydrology of the Eastern Mojave River Drainage, Southern California
PERFORMING ORGANIZATION:	New Mexico State University Las Cruces, NM 88003
PRINCIPAL INVESTIGATOR:	Stephen G. Wells
DATES:	September 1, 1986, through August 31, 1988

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. Deciphering paleohydrologic regimes and their climatic significance is essential for (1) assessing historic hydrologic processes and their variations, (2) modeling regional or global changes in climate, and (3) predicting future trends related to planning of hazardous-waste disposal. The Mojave River drainage basin of southern California is a closed hydrologic system (> 7900 km^2) in an arid environment and contains geologic features related to late Quaternary variations in hydrologic regimes. The site is located close to the Pacific Ocean from which the major runoff-producing storms originate and contains relicts of past hydrologic regimes which may be recorded in the sediment record. Important geologic features include radiocarbon-dated shorelines related to late Quaternary paleo-lake development, paleo-sheetflood deposits related to high-magnitude flood events on desert piedmonts, and soil profiles which reflect different soil moisture/leaching regimes. In addition, the watershed has welldocumented, historic hydrologic data (precipitation, runoff, and lake evaporation).

2. Contribution to problem solution. The combination of well-dated late Quaternary hydrologic features and the historic hydrologic record of the Mojave River floods and modern lake stands provides a unique opportunity for determining the variability of hydrologic regimes and climate in a large arid watershed for the past 15,000 years. The Mojave River flows from the Transverse Range eastward to its terminus at Silver Lake/Soda Lake playas which are the site of former pluvial lake Mojave. In historic times, the playas contain water only after extreme flooding of the Mojave River in response to large precipitation events in the Transverse Range. Three major runoff events and their associated lakes occurred in 1916, 1938, and 1969.

3. Objectives. The primary goal of this project is the quantification of major components of the hydrologic cycle (precipitation, evaporation, runoff, and soil-leaching conditions) for the late Quaternary in order to reconstruct the variations of past hydrologic regimes.

4. Approach. To achieve this goal, two secondary goals will be undertaken: (1) the paleolimnologic analysis of pluvial Lake Mojave (which existed from 15,000 to 8,000 years ago) and the paleohydrologic analyses of Mojave River flood deposits, sheetflooding on adjacent desert piedmonts, and soil-forming processes; and (2) the analyses of historic hydrologic records (runoff, precipitation, evaporation) as calibration points for estimates of the paleo-hydrologic regimes. Field studies include: (1) drilling and sampling pluvial-lake sediments; (2) measurements of the geometry of paleo-channels, grain sizes of flood deposits, bedform morphology of flood sediments, height and extent of slackwater sediments; (3) mapping; and (4) describing soil profiles. The investigators will develop a unified quantitative model based upon the several physical indicators and coupled with computer analyses of modern hydrologic events.

5. Result users. The results will be useful to climatologists in predicting future trends.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G-1316
PROJECT TITLE:	An Assessment of the Relationship Between Climate and Streamflow Variability Using Water-Balance Models
PERFORMING ORGANIZATION:	Portland State University Portland, OR 97207
PRINCIPAL INVESTIGATOR:	Roy W. Koch
DATES:	September 16, 1986, through September 15, 1988

PROJECT DESCRIPTION

1. Identification of the water or water-related problems and problem-solution approach. An evaluation of the attenuation or amplification of climatic variability through the hydrologic cycle and the resulting effect on streamflow requires physically based models of the relevant processes involved in the transformation. In addition, long-term forecasting of streamflow is depends on reliable, long-term forecasts of climatic inputs as well as effective models for computation of streamflow. Water-balance models based on monthly or seasonal time scales can be developed for use in both problems.

2. Contribution to problem solution. Such models can be used to quantitatively assess the effects of climate anomalies as reflected in streamflow, to help in understanding the mechanisms for the response, and ultimately to provide a tool for use in long-term forecasting of streamflow using long-term climate forecasts.

3. Objectives. The primary objective of this research is to test the hypothesis that physically realistic water-balance models can be developed for varying hydrologic environments and that such models have utility in both predicting streamflow and providing a tool for understanding the mechanisms of transformation. Finally, given the inherent error in such models due to integrations over time and space and the nature of the inputs, an evaluation of the acceptable error of input for providing streamflow forecasts is proposed.

4. Approach. The approach is to select three areas of differing hydrologic character and climate and proceed to develop water-balance models on monthly and seasonal time scales. This will be accomplished by formulating hypotheses on relevant processes and their behavior and developing tests of the hypotheses which can be carried out using data on observed streamflow, precipitation, and temperature as well as knowledge of the ongoing hydrologic processes. Model error will be evaluated to assess the predictive capability of the model and the structure of the errors. Finally, an uncertainty analysis will be undertaken to identify the contribution to error variance by model error and input error, assuming the inputs are uncertain.

5. Result users. The modeling process, the models and the assessment of input-error variance will be useful in the area of water-supply forecasting. The model behavior will be useful in developing a better understanding of how climate anomalies affect streamflow and may form a basis for feedback to climate models.

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