WATER RESOURCES RESEARCH GRANT PROGRAM

PROJECT DESCRIPTIONS, FISCAL YEAR 1991

Compiled by Melvin Lew and Pamela Murray

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CONTENTS

Page

Page

Page

LIST OF TABLES

Page

Table:

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ABSTRACT

This report contains information on the 36 new projects funded by the U.S. Geological Survey's Water Resources Research Grant Program in fiscal year 1991 and on 41 projects completed during the year. For the new projects, the report gives the grant number, project title, performing organization, principal investigator(s), project duration, and a project description that includes: (1) identification of water-related problems, (2) contribution to problem solution, (3) objectives, and (4) approach. The 36 projects include 5 in the area of biological sciences, 8 in climate and hydrologic processes, 4 in engineering, 6 in ground-water flow and transport, 8 in social sciences and 5 in water quality.

For the 41 completed projects, the report gives the grant number, title, performing organization, principal investigator(s), starting date, date of receipt of final report, and an abstract of the final report. Each project description provides the information needed to obtain a copy of the final report.

The report also contains tables showing (1) proposals received according to area of research interest, (2) grants awards and funding according to area of research interest, (3) proposals received according to type of submitting organization, and (4) awards and funding according to type of organization.

INTRODUCTION

In January 1985, the U.S. Geological Survey was assigned responsibility for administering the Water Resources Research Act of 1984 (Public Law 98-242). Section 105 of the act authorizes funds for research grants, on a fund-matching basis, to qualified individuals and groups as defined in the law. Each year an announcement is issued to solicit proposals for research support from the funds appropriated by the Congress.

In fiscal year (FY) 1985, 24 of 368 proposals that were submitted were selected for funding with the $2.543 million appropriated by Congress. In FY 1986, 43 of 299 proposals were selected for funding with the $4.767 million appropriated; in FY 1987, 34 of 273 proposals were selected for funding with the $4.381 million appropriated; in FY 1988, 38 of 239 proposals were selected for funding with the $4.381 million appropriated; in FY 1989, 36 of 260 proposals were selected for funding with the $4.381 million appropriated; and in FY 1990, 40 of 250 proposals were selected for funding with the $4.322 million appropriated. These projects are described in U.S. Geological Survey Open-File Reports 85-687, 86-548, 88-179, 89-249, 90-139, and 91-195, respectively.

In FY 1991, 315 proposals requesting $37.4 million of Federal funding ($38.9 million of non-Federal funding) were submitted in response to U.S. Geological Survey Announcement No. 7719 issued on August 7, 1990. Of this number, 36 were selected for funding with the $4.358 million appropriation (Table 1). As in previous years, proposals from academic institutions dominated the competition for grants funds (Table 2).

Section I of the report presents summaries of the 36 proposals selected for funding. Section II presents summaries of the 41 projects completed during FY 1991.

Table 1--Proposals and Awards by Research Interest Area, Fiscal Year 1991

Proposals

Interest Area	No.	Federal Funds ($)	Non-Federal Funds ($)	Total Funds ($)
Ground-water Flow and Transport	64	7,620,452	8,156,000	15,776,452
Engineering	64	7,073,357	7,340,120	14,413,477
Water Quality	53	6,504,915	6,710,301	13,215,216
Biological Sciences	40	4,911,005	5,094,942	10,005,947
Social Sciences	40	4,478,908	4,676,720	9,155,628
Climate and Hydrologic Processes	54	6,811,034	6,956,299	13,767,333
Totals	315	37,399,671	38,934,382	76,334,053

Awards

Interest Area	No.	Federal Funds ($)	Non-Federal Funds ($)	Total Funds ($)
Ground-water Flow and Transport	6	651,990	681,504	1,333,494
Engineering	4	626,278	631,334	1,257,612
Water Quality	5	674,204	681,408	1,355,612
Biological Sciences	5	638,624	664,112	1,302,736
Social Sciences	8	895,304	935,109	1,830,413
Climate and Hydrologic Processes	8	871,600	885,222	1,756,822
Totals	36	4,358,000	4,478,689	8,836,689

Table 2.--Proposals and Awards by Organization, Fiscal Year 1991

Proposals

Organization	No.	Federal ($)	Non-Federal Funds ($)	Total Funds($)
Academic Institutions	304	36,263,338	37,731,771	73,995,109
Non-Federal Government	3	388,084	388,084	776,168
Private	8	748,249	814,527	1,562,776
Total	315	37,399,671	38,934,382	76,334,053

Awards

Organization	No.	Federal ($)	Non-Federal Funds ($)	Total Funds ($)
Academic Institutions	36	4,358, 000	4,478,689	8,836,689
Non-Federal Government	0	0	0	0
Private	0	0	0	0
Total	36	4,358,000	4,478,689	8,836,689

SECTION I

PROJECT SUMMARIES

FISCAL YEAR 1991 GRANTS

BIOLOGICAL SCIENCES

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G2098
PROJECT TITLE:	Microbial Transformation of Organic Sulfur Compounds in Saline Ecosystems
PERFORMING ORGANIZATION:	Oregon Graduate Institute of Science and Technology
PRINCIPAL INVESTIGATOR:	D. Boone
DURATION:	September 1991 to September 1994

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

The current level of understanding of microbial processes occurring in ground-water brines, hypersaline lakes, and estuaries is poor, although these systems are important sources of key atmospheric gases such as methane and dimethylsulfide. The global cycles of these two gases are extremely important in models of global warming, yet current estimates of the fluxes of these gases from terrestrial and marine sources to the atmosphere do not match the estimates based on atmospheric chemistry. The important biological sources of dimethylsulfide from any environment and of methane from saline environments appear to be "compatible solutes," i.e., organic intracellular solutes which biological cells form to balance the water activity of their cytoplasm with that of their saline environment. Three common compatible solutes are trimethylamine oxide, glycine betaine, and dimethylsulfonio-propionate, which lead to trimethylamine and dimethylsulfide upon decomposition in anoxic environments. Trimethylamine and dimethylsulfide in turn are decomposed by methanogens to methane and carbon dioxide (plus ammonia or hydrogen sulfide).

2. Contribution to the Problem Solution.

This project will extend our understanding of microbiological processes in estuaries and thus improve our understanding of the impact of changes in that environment. The research would add considerably to our understanding of specific microbial processes occurring in the ground-water brines, hypersaline lakes, and estuaries which impact the atmosphere.

3. Objectives.

The objectives of this research are to:

(a) determine the concentrations of the precursors of methane (*viz.*, the compatible solutes glycine betaine and dimethylsulfoniopropionate which are degraded to trimethylamine and dimethylsulfide, the ultimate precursors of methane) in sediment microbes and interstitial water from one or more sites in the Columbia estuary, which experiences wide tidal swings in salinity;

(b) isolate predominant sulfate-reducing bacteria and methanogens from the anaerobic zone of the sediment and test their response (i.e., production, uptake, or release of compatible solutes) to fluctuations in salinity; and

(c) examine the biochemical pathways of dimethylsulfide degradation by methanogens from the estuary and other previously isolated methanogens by examining intermediate products formed during dimethylsulfide degradation and specific enzymatic activities.

4. Approach.

Compatible solutes are important constituents of cells growing in saline environments, but when the cell grows in an unchanging environment very little may be released. Compatible solutes are amphoteric, so loss by diffusion through the cell membrane is minimal. However, if cells are exposed to changing salinity, they must adjust the salinity of their cytoplasm to match that of their environment. This adjustment is generally accomplished in a specific order: (1) adjustment of cell volume by passage of water; (2) release or uptake of inorganic solutes; and (3) release, uptake, or synthesis of organic solutes. The latter two of these mechanisms cause turnover of compatible solutes by making them available for decomposition by other organisms. In estuaries, salinities are constantly changing, so organisms must be constantly adjusting their salinities. We will identify sampling sites in the Columbia estuary, selecting zones with wide salinity fluctuations (based on collected data and computer models of colleagues). We will collect samples of pore water from the upper layers of sediments and of the upper sediments themselves during various periods of the salinity cycles. Compatible solutes and their degradation products will be extracted from the sample and analyzed, to determine changes in intracellular and extracellular concentrations of the solutes during tidal cycles. We will isolate the numerically important organisms from the

sediments and examine their formation of compatible solutes in controlled *in vitro* experiments in which the salinity is varied. The second branch of this research will examine the conversion of dimethylsulfide to methane and hydrogen sulfide. This conversion has been documented in several strains of methanogenic bacteria, but many significant questions remain unanswered regarding this degradation. Our preliminary evidence indicates that the metabolic pathways are significantly different than those used for conversion of other methyl substrates, and suggests some unusual new pathways. We will attempt to determine the initial enzymatic reactions leading to the degradation of dimethylsulfide, and whether free methanethiol is an intermediate in the complete mineralization of dimethylsulfide. We will also provided cultures of methanogens grown on dimethylsulfide to be tested for dimethylselenide decomposition.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G2099

PROJECT TITLE: Structural and Functional Responses of Benthic Communities to Heavy Metals: Variation Along Longitudinal Stream Gradients

PERFORMING ORGANIZATION: Colorado State University

PRINCIPAL INVESTIGATOR: W. Clements

DURATION: August 1991 to August 1994

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

Field approaches for investigating the effect of heavy metals on stream ecosystems are often confounded by longitudinal variation in community structure and function. In addition, it is hypothesized that sensitivity to stress also varies from upstream to downstream.

2. Contribution to the Problem Solution.

This research will compare responses of benthic communities to metals measured in stream microcosms with responses observed at impacted field sites. Longitudinal variation in sensitivity to metals will be examined by comparing responses of benthic communities obtained from headwater and mid-order streams.

3. Objectives.

The objectives of this research are to:

(a) test the hypothesis that responses of benthic communities to heavy metals measured in experimental streams can be employed to predict responses of these communities in the field; and

(b) test the hypothesis that structural and functional responses of benthic communities to metal varies along longitudinal stream gradients.

4. Approach.

Experiments will be conducted in stream microcosms using natural communities of benthic organisms (periphyton and macroinvertebrates) collected from undistributed Colorado streams. Benthic communities established in stream microcosms will be dosed with heavy metals (Cd, Cu, Pb, Zn) at concentrations similar to those measured at impacted sites in the Arkansas River, a Colorado stream receiving mine discharges. Structural and functional responses of benthic communities to metals in selected streams will be compared to those observed at field sites in the Arkansas River and other metal-impacted streams. Longitudinal variation in sensitivity to metals will be investigated by comparing responses of benthic communities obtained from headwater and mid-order streams.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G2100
PROJECT TITLE:	Freshwater Mussels as Rapid In Situ Indicators of Pollutants
PERFORMING ORGANIZATION:	Pennsylvania State University
PRINCIPAL INVESTIGATOR:	F. Williams
DURATION:	August 1991 to August 1993

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

A need has long been recognized for continuous, rapid, in situ, water-quality biomonitoring. Such monitoring has been tested with some success using fish and aquatic insects as indicator organisms. Freshwater mussels, which are extremely sensitive to most organic and inorganic pollutants, have yielded little success so far.

Most previous attempts to capitalize on mussels as indicator organisms have involved either sacrifice of the animals for tissue analysis or intrusive surgical techniques to enable bioelectrical monitoring. Automated monitoring of mussel behavior has had less success than for other invertebrate or vertebrate assay species, not because of the mussels' unresponsiveness but because of measurement problems.

2. Contribution to the Problem Solution.

This research is devoted to development of the appropriate measurement systems, using current state-of-the-art electronics, and to provide the baseline data needed for deployment of mussels, either as stand alone biomonitoring systems or for use in conjunction with multi-species monitoring systems.

Once the methodology is perfected, we can realize the potential benefits of including mussels as components of automated real-time monitoring programs. Being by nature sedentary, mussels are much easy to collect, maintain, install in enclosures, and replace when needed then fish and aquatic insects.

3. Objectives.

The objective of this study is to evaluate the usefulness of freshwater mussels as continuously active, rapid biomonitors of in situ water-pollution episodes.

4. Approach.

The approach will include non-intrusive electronic monitoring of valve opening and closing rhythms of 20 - 30 freshwater mussels housed in an enclosure in a stream or river, with the resulting amplified signals being transmitted to data loggers on shore. Such data, after A/D conversion, can be analyzed statistically on a personal computer or sent to a central processing center via any terrestrial or satellite telecommunications method.

The first phase is to evaluate effectiveness of several signal transduction methods for measuring mussel valve position. Several devices, measuring resistance, capacitance, or water conductance, will be tested under natural flowing water conditions. Methods of amplification, transmission, and recording will be state-of-the-art but standard. Statistical procedures will take into account not only species-specific activity rhythms but also individual responses to environmental variability. Parameters of interest include phase and duration of active and resting periods as well as magnitude of the gape.

The second phase is to test sensitivity and reliability of the mussels' behavior. In situ behavior patterns will be compared with those of mussels in a similar chamber, receiving water pumped from the field site, but housed in a nearby laboratory. These baseline comparisons will enable us to (1) determine the extent to which bioindicator sensitivity in, for example, a mobile laboratory compares with that in the natural site, and (2) provide an opportunity to test sensitivity to various organic and inorganic toxicants added to the water in the laboratory by standard flow-through diluters.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G2101
PROJECT TITLE:	Impact of Cyanobacterial Metabolites on Water Quality
PERFORMING ORGANIZATION:	University of New Hampshire
PRINCIPAL INVESTIGATOR:	J. Sasner
DURATION:	July 1991 to June 1993

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

Eutrophic waters harboring toxic cyanobacterial blooms (blue-green algae) have been reported in at least 26 countries, including 4 Canadian provinces and 21 U.S. States. Animal mortalities associated with these blooms have been attributed to primarily 2 different types of toxins. One type contains nerve membrane toxins called aphantoxins, which block sodium channels and destroy nerve impulse conduction in neuromuscular systems. The other group contains cyclic peptides called microcystins, which destroy liver tissues in animals that drink from bloom water. The sublethal effects of these cyanobacterial metabolites, their stability over time, and their accumulation/transmittance through freshwater food chains and drinking water supplies are not understood. Such investigations were not easy to conduct until now because: a) water scientists did not know what chemicals to look for, and (b) even when the chemical were found, sensitive assay methods were not available to analyze them.

2. Contribution to the Problem Solution.

Recently aphantoxins and microcystins have been purified, their analogues characterized, and sensitive high performance liquid chromatography (HPLC) and cell culture methods for their detection and assay have been developed. This study will use these discoveries in basic metabolite chemistry and assay methods to assess the presence of aphantoxin and microcystin during and after blooms, and also measure the impact of sublethal concentrations on primary consumers at the base of freshwater food chains.

3. Objectives.

The objectives of this research are to:

(a) measure and evaluate the impact of cyanobacterial metabolites/toxins in eutrophic lakes and ponds; and

(b) test the hypothesis that aphantoxin and microcystin decrease the ability of primary consumers (grazers) to convert algal productivity into zooplankton energy by altering their feeding and vertical migratory behavior.

4. Approach.

This study will employ new HPLC and cell culture bioassay methods for detecting cyanobacterial metabolites in lab cultures and natural water samples, during and after blooms. To test the second hypothesis, the study will use model primary consumer species and measure feeding rates, migration patterns and energy conversion rates under controlled conditions.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G2102
PROJECT TITLE:	Biotransformation of Chlorobenzene and Aromatic Hydrocarbons Under Denitrifying Conditions
PERFORMING ORGANIZATION:	Johns Hopkins University
PRINCIPAL INVESTIGATOR:	E. Bouwer
DURATION:	July 1991 to June 1993

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

Aromatic hydrocarbons from leaking underground storage tanks, landfills, toxic waste sites, and oil spills are common contaminants in surface water and ground-water resources. The importance of anaerobic microbial processes in the environmental fate of these petroleum products is unclear, and the extent to which anaerobic processes can be successfully used in bioremediation of contaminated soils and ground-water is unknown.

2. Contribution to the Problem Solution.

This research will provide knowledge about stoichiometry, kinetics, and reaction pathways for denitrification of certain problematic aromatic hydrocarbons. This information can be used to improve existing transport and fate models, to design efficient and cost effective treatment methods, and to increase our understanding of biochemical processes which may later prove useful in biotechnology.

3. Objectives.

The overall goal of this research is to characterize the biotransformation of a model aromatic hydrocarbon, chlorobenzene, under anaerobic conditions with nitrate serving as the terminal electron acceptor. Specific research objectives include: (1) developing a denitrifying culture which is able to utilize chlorobenzene as the sole source of carbon and energy; (2) evaluating the effects of pH, chlorobenzene concentration, and nitrate concentration on biodegradation rates and stoichiometry; and (3) identifying metabolic

intermediates associated with the catabolism of chlorobenzene in order to determine the mechanisms responsible for the initial metabolic steps which transform chlorobenzene into common metabolic intermediates under denitrifying conditions.

4. Approach.

The basic approach will be to conduct batch experiments and operate porous media flow biofilm reactors with defined denitrifying cultures. Chlorobenzene degrading cultures will be developed from denitrifying cultures which degrade a mixture of benzene, chlorobenzene, toluene, and m-xylene. Batch experiments will be used to evaluate the effects of the three environmental factors on initial biodegradation rates and identify conditions which optimize contaminant removal or promote the accumulation of metabolic intermediates in culture fluids. Culture fluids from batch reactors and biofilm column reactors will be analyzed by gas chromatography/mass spectrometry techniques to detect and identify metabolic intermediates. Radio-labelled chlorobenzene will be used in experiments to confirm intermediates by autoradiography. If intermediates are detected in culture fluids, then experiments with $H_2{}^{18}O$ will be used to determine if water is the source of oxygen for oxygenated intermediates. Based on the results of these experiments a metabolic pathway for chlorobenzene degradation will be proposed.

CLIMATE AND HYDROLOGIC PROCESSES

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G2107

PROJECT TITLE: Hydrometeorological Modeling for Climate Studies

PERFORMING ORGANIZATION: Princeton University

PRINCIPAL INVESTIGATOR: J. Smith

DURATION: July 1991 to July 1994

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

Changes in the spatial and temporal patterns of precipitation are indicated as likely consequences of climate change induced by increased carbon dioxide. The impacts on water resources systems, and more generally terrestrial ecosystems, are clearly among the most significant issues associated with climate change. Our capability for assessing changes in precipitation climatology, however, is disturbingly poor. Atmospheric general circulation models (GCM) provide conflicting information on changes in long-term mean precipitation patterns (annual/seasonal) and virtually no information on potential changes in the precipitation climatology of extreme events. Water resources systems are typically most sensitive to changes in characteristics of extreme events.

2. Contribution to the Problem Solution.

Development of sub-grid scale precipitation models that accommodate information on large-scale meteorological processes, to be researched in this study, is an important step in bridging the gap between GCM information and the information required for carrying out regional water-resources assessment.

3. Objectives.

The objectives of this research are to:

(a) characterize the climatology of precipitation in the southern plains of the Unites States using radar rainfall data, hourly rain gage data, and surface and upper air observations for storm periods;

(b) develop a statistical model of precipitation that incorporates pertinent meteorological information, as determined in (a), and that accurately represents space-time structure of storm rainfall, as determined in (a). The time-increment of the model will be no coarser than 6 hours and the spatial grid will be approximately 4 km;

(c) develop statistical inference procedures for model selection and for estimating parameters of the model;

(d) convert the statistical model into a simulation model that operates on a time increment no coarser than 6 hours and a spatial grid of approximately 4 km; and

e) develop computational results for the model that enhance its utility for climate studies.

4. Approach.

The model developed in this study is intended primarily for use in regional assessments of water resources impacts associated with climate change. A particular class of statistical models, termed Cox processes, plays a central role in model development. Cox process models are attractive for two principal reasons: 1) spatial heterogeneities of model components and meteorological observations can be easily and naturally accommodated, and 2) Cox process models have been demonstrated to be computationally tractable, especially for problems of parameter estimation and precipitation frequency analysis. The southern plains of the United States will be used as the principal study region of this research. This region exhibits a sharp gradient in the climatological pattern of precipitation. Climate ranges from humid to semi-arid along an east-to-west transect of less than 500 km. Superimposed on the spatial pattern of precipitation are pronounced seasonal and diurnal components. The southern plains is a sensitive site to climate change due to the pronounced climate gradients and human activities. It is also a well instrumented site for studying precipitation. Of particular importance will be the early and dense deployment of weather radars under the Next Generation Weather Radar (NEXRAD) program. Model development will be based on data analysis studies that utilize radar and rain gage observations of precipitation, and surface and upper air observations of meteorological variables.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G2108

PROJECT TITLE: Cyclic Flexure of Surficial Strata in Response to Seasonal Ground-water Withdrawal from the Mimbres Basin, New Mexico

PERFORMING ORGANIZATION: New Mexico State University

PRINCIPAL INVESTIGATOR: W. Haneberg

DURATION: July 1991 to July 1992

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

Deformation of surficial sediments in response to ground-water withdrawal, particularly in the arid western states, has the potential to damage civil works such as highways, bridges, aqueducts, and buildings. Cavernous earth fissures related to ground-water withdrawal and subsidence provide contaminants with a pathway to water supplies. Subsidence and fissuring have been documented during reconnaissance studies of the Mimbres Basin, and the results of a detailed seismic reflection survey show that one fissure lies above a series of buried normal faults in basin-fill sediments. Based upon this knowledge, as well as the results of other field studies, it is believed that changing effective stress due to seasonal ground-water withdrawal will produce movement along the buried faults, thereby deforming the overlying sediments.

2. Contribution to the Problem Solution.

The combination of field observation and theoretical analysis will allow evaluation of the mechanical model as a predictive tool for ground-water scientists and engineers. Incorporation of both stress and displacement boundary conditions will allow either back-calculation of stresses and displacements in a previously deformed layer or prediction of deformation and subsidence associated with aquifer dewatering.

3. Objectives.

The objectives of this research are to:

(a) observe the deformation of surficial strata in response to seasonal groundwater level fluctuations; and

(b) determine whether mechanical models of monoclinal flexure adequately describe the observed deformation.

4. Approach.

Deformation will be documented using extremely sensitive borehole tiltmeters (0.1 ppm rotation), originally developed to monitor surface deformation associated with the growth of oilfield hydrofractures, and compared with seasonal water level fluctuations. Observed displacement fields will then be compared to theoretical models, developed by the principal investigator during previous research projects, of stress and displacement fields in elastic layers subjected to monoclinal flexure.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G2109
PROJECT TITLE:	Mapping the Boundary Between Continuous and Discontinuous Permafrost in Alaska
PERFORMING ORGANIZATION:	University of Michigan
PRINCIPAL INVESTIGATOR:	A. England
DURATION:	August 1991 to July 1994

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

The boundary between continuous and discontinuous permafrost represents a division between a climatic region which is sufficiently cold that it supports perennial ground ice and a region which is less cold. Because permafrost represents the integrated effects of many seasons, the migration of this boundary is potentially a good indicator of longer term, global climatic change. However, local shifts in the boundary may indicate only variation in dominant patterns of local or regional weather, that is, variation in local or meso-scale climate. To relate local change to global climate change, the migration of the continuous/discontinuous boundary should be mapped on a polar scale.

2. Contribution to the Problem Solution.

The monitoring of polar scale phenomena is best done by satellites--preferably satellites that are already operational. Furthermore, it isn't enough to monitor changes in periglacial morphology, because such changes may not reveal a recent loss of permafrost. This research will develop a technique for mapping changes in the boundary between continuous and discontinuous permafrost based upon temporal patterns in the seasonal freezing of the active layer. The technique will use data from an existing operational radiometer, the Special Sensor Microwave/Imager (SSM/I), which is part of a series of Defense Meteorological Satellites.

3. Objectives.

The objectives of this research are to:

(a) develop a radiobrightness thermal model for the annual freezing and thawing of soil;

(b) determine the sensitivity of the model to the existence of underlying permafrost;

(c) evaluate the consistency of that model with data from the SSM/I;

(d) test the quality of the model with a limited field experiment; and

(e) produce a three year map of the continuous/discontinuous permafrost boundary in Alaska.

4. Approach.

A diurnal model will be expanded for the radiobrightness of freezing and thawing soils to cover an annual cycle. A parametric study using the model will determine its sensitivity to the existence of permafrost. Based upon preliminary modeling, we expect that the onset of soil freezing and thawing, and the diurnal persistence of soil freezing and thawing, will be modified by underlying permafrost. The predictions of the model will be applied to existing SSM/I data and checked for self-consistency. Discrepancies between the model and the observations will be cast as questions for a field experiment to be undertaken at a single site during the fall and early winter of the second year of the experiment. Results of the field experiment will be used to refine the model, which in turn should permit estimates of the boundary location in Alaska during the three year period of the experiment.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G2110

PROJECT TITLE: A Spatially Distributed Water Balance Based on Physical, Isotopic, and Airborne Remotely Sensed Data

PERFORMING ORGANIZATION: Utah State University

PRINCIPAL INVESTIGATOR: C. Neale

DURATION: August 1991 to August 1993

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

Water balance models are critical to hydrologists and water resource planners in calculating basin yields, estimating flows from ungauged tributaries, assessing drought risks, and determining the effects of climate or land use changes. Semi-arid environments are particularly sensitive. The models typically used employ lumped representations of hydrologic processes defined over one or more zones within a basin. While such models can be calibrated to give reasonable results, they do not adequately resolve the spatial distribution of component processes. Therefore extreme caution must be used in attaching physical significance to model parameters.

2. Contribution to the Problem Solution.

This research will develop a spatially distributed water balance model with physically meaningful parameters and state variables. Airborne near-infrared and visible video imagery will be used to develop procedures for estimating and integrating spatially distributed hydrologic fluxes, using state-of-the-art techniques coupled with intensive field measurements. Model output will be checked by field measurement, isotopic tracing and remote measurements.

3. Objectives.

The objective is to develop a water balance model based on the integration of spatially distributed data. The research will describe as completely as possible in space and time, all water fluxes in the basin and obtain a water balance

closure. Specifically, the modeling approach will combine routine field and meteorological observations with remote sensing, to obtain a spatially distributed representation of hydrologic fluxes. Detailed experimental field observations will be used for validation.

4. Approach.

The research will focus on the spatial distribution of evapotranspiration, precipitation, snowmelt and soil moisture for determining a water budget at each grid cell. The model and measurements will be incorporated into a Geographic Information System (GIS) for analysis. The analysis will determine the integrated effect of these processes on streamflow and groundwater. It is planned to use two sub-catchments in the Reynolds Creek experimental watershed. The highly instrumented Sheep Creek sub-catchment will be used to develop and calibrate our models and then the nearby Reynolds mountain sub-catchment will be used for validation. The approach is unique in its combination of modeling, field measurements, isotope tracing, and remote sensing techniques to address water balance problems.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G2111

PROJECT TITLE: Chemical Erosion and Development of the Regolith on a Steep Hillslope

PERFORMING ORGANIZATION: University of California at Berkeley

PRINCIPAL INVESTIGATOR: W. Dietrich

DURATION: July 1991 to June 1993

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

In steep lands where the regolith is thin, erosion is in part controlled by the rate of production of erodible material. This production rate must be influenced by chemical processes that remove mass, generate porosity, and change material resistance to transport. Although, geomorphologists have inferred a coupling between the thickness of regolith and the rate of the regolith development, there are no data to support this inference. A "transport law" is needed that predicts the spatial dependence of solute flux along subsurface flow lines off hillslopes for geomorphic time scales. This is a very broad problem relevant to theoretical questions concerning prediction of hillslope form and evolution and relationships between climate, tectonics and landscape erosion rates, as well as more practical issues regarding prediction of solute flux to channels and its dependence on land use.

2. Contribution to the Problem Solution.

The research will contribute significantly to the solution of this problem by generating field data on processes, spatial divergence of fluxes, and regolith properties that can be used to test various solute erosion theories.

3. Objectives.

The objectives of this research are to:

(a) document the geochemical evolution of water following well-defined shallow subsurface flow paths through soil and weathered rock; and

(b) relate these fluxes via a transport law to observed mass balance changes during regolith development.

4. Approach.

The research will be pursued along two lines. First, on an already heavily instrumented, small ($860m^2$), steep (43 degrees), unchanneled valley we will perform artificial rain experiments that will bring the site to equilibrium response. We will monitor solute concentration changes along well-defined flow paths through the shallow soil and weathered rock layer such that the spatial divergence of solute flux can be calculated. Natural runoff concentrations and solute flux rates will also be determined. Importantly, previous studies have already given estimates of average erosion rates, annual solute fluxes, mean residence time of soil on hillslopes, and rate of weathered rock production. Second, we will perform mass-balance analyses of soils, weathered rock, and underlying rock in order to define the net loss of mass and the strain (expansion or collapse) associated with weathering. The two lines will then be combined by using observed solute fluxes to predict documented changes in regolith geochemistry. This research will document the geochemical evolution of waters along well-defined flow paths under conditions of constant runoff on a small catchment scale and relate such measurements to the evolution of the regolith.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G2112
PROJECT TITLE:	Characterization and Prediction of Drainage Networks of Field-Sized Areas
PERFORMING ORGANIZATION:	University of Minnesota
PRINCIPAL INVESTIGATOR:	B. Wilson
DURATION:	September 1991 to September 1994

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

Physically-based simulation models are widely used to assess and manage runoff and pollutants from nonpoint sources. The detachment, entrainment, and transport processes in field-sized areas are the primary sources of contaminants and therefore must be modeled accurately. Most physically-based models currently use crude methods, usually assuming sheet flow, to describe hydraulic processes. Sheet flow rarely occurs in nature. Flow paths converge with other flow paths to form small channels. Velocity and bed shear in these small channel are essential in determining detachment, entrainment, and transport and are significantly different than those obtained with sheet flow assumptions. Alternative approaches are therefore needed to represent overland flow. Since it is unlikely that enough data will ever be available to describe deterministically the actual flow paths, these approaches should include the unavoidable uncertainty in predicting flow paths.

2. Contribution to the Problem Solution.

The concept of topologically random channel networks has been successfully used to describe the drainage network of river systems. In comparison to rill networks, these drainage systems are already developed and their major features can be determined from map data. A more powerful application of topologically random channel networks is to predict the development of rill networks as the result of future storms. This step has not yet been used but should prove valuable in characterizing the runoff process in field-sized areas. Not only can flow paths be predicted but the uncertainty of a particular drainage pattern can also be determined. The application of this approach to upland processes of runoff and erosion is the thrust of this research.

3. Objectives.

The objectives of this research are to:

(a) gather and analyze drainage network data resulting from erosion in field-sized areas using parameters of geomorphology;

(b) develop a predictive model for drainage network development and erosion processes using concepts of topologically random channel networks and geomorphoric assumptions for link lengths and area properties; and

(c) evaluate the assumption of random channel networks and the resulting predictive model.

4. Approach.

Data will be gathered to measure drainage networks of field-sized areas using a unique indoor research facility and field data. This information by itself will provide useful information about similarities of drainage basins. The second component of the project is the development of a model to predict flow paths using geomorphologic relationships. Uncertainty in flow paths will be assessed using the topologically random network theory as developed by Shreve. The validity of this approach will be evaluated using an independent data set.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G2113

PROJECT TITLE: A Study of Cool, Warm, and Wet Episodes in the Western United States

PERFORMING ORGANIZATION: University of California at San Diego

PRINCIPAL INVESTIGATORS: J. Roads and S. Chen

DURATION: September 1991 to September 1994

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

Hydrologic characteristics associated with precipitation-bearing storms and droughts in the western United States need to be better understood. Such meteorological extremes are important for determining characteristics of the surface-water supply; rainfall runs off almost immediately to the streams during warm years or can be stored in snowfall to be released much later in the water year during cold years. With the increasing demand for water in the western United States, such future extreme variations will become increasingly important. If the global climate warms, surface hydrological characteristics will be substantially influenced by changes in the precipitation amount and character (rain or snow) as well in evaporation. Hydrologists must understand better the characteristic features associated with warm and cool storms as well as warm and cold seasons in the western United States if we are to be able to predict interannual and longer term variations in precipitation and ultimately the surface hydrology.

2. Contribution to the Problem Solution.

This research will identify better the atmospheric structure associated with and responsible for the western United States hydrological extremes. In particular, the research will identify, from the observations, meteorological characteristics associated with warm, cool, wet, and dry conditions in the western United States. The work will also evaluate a general circulation model which can be used to predict these extreme conditions. The large-scale diagnosis of the observations and large-scale predictability study with the general circulation model will be complemented by a diagnosis of warm and cold precipitation

events with a small-scale model capable of much greater resolution. The small-scale model will be used to help develop detailed snow and precipitation fields associated with warm, cold, wet, and dry years.

3. Objectives.

The basic objective of this research is to better understand the characteristic large scale meteorological and precipitation patterns associated with hydrological extremes in the western United States. By using a hierarchy of data and models we intend to determine how these hydrological extremes are related to the larger scale atmospheric circulation, and also determine the associated fine-scale snow and rain differences over the West. A longer term objective is to further develop our capability to model hydrological extremes.

4. Approach.

The research will develop criteria to characterize warm, cool, wet, and dry extremes in the far west. Daily to monthly time scales will be examined. We will diagnose from the available meteorological record the characteristic large-scale circulation patterns associated with warm, cool, wet, and dry circulations. Earlier events can only be characterized by the surface or 700 mb circulation; more recent events can be described better from the objective analysis of more comprehensive data produced as a byproduct of weather forecasting. We will determine if the relevant hydrological patterns can be simulated by a general circulation model. We are particularly interested in determining the antecedent evolution of the characteristic patterns so that we can predict their occurrences. Finally, we will describe the characteristic small-scale features of such circulations with a fine mesh model and available station data.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G2158
PROJECT TITLE:	Simulation of Effects of Climatic Change on Surface-water Balances of Agricultural Lands
PERFORMING ORGANIZATION:	Texas A&M University
PRINCIPAL INVESTIGATOR:	J. Heilman
DURATION:	September 1991 to September 1993

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

If predictions of climatic change are correct, water balances of agricultural lands may be substantially altered. This may affect plant growth and yield by changing duration, severity and timing of water stress, and may control how much water must be applied to irrigated agriculture. Unfortunately, there is little basis for comparison when evaluating possible impacts of climatic change because little information exists on how plant and soil energy balances, transpiration and soil evaporation vary with climatic regime under current conditions. Previous studies have used empirical crop models which do not accurately account for interaction of plants with atmospheric and soil environments, or have used evapotranspiration (ET) models which do not allow for separate analysis of soil evaporation, transpiration and soil water content.

2. Contribution to the Problem Solution.

The research utilizing a physically-based ET and water balance model will provide new information on how existing conditions affect ET and the surface-water balance over a wide range of climatic conditions. In addition, it will provide realistic assessments of how water balances may be affected by climatic change. This information will be important for strategic planning to prepare for a change in the water balance that may occur as a result of climatic change.

3. Objectives.

The objective of the proposed research is to determine how global warming may affect surface water balances of agricultural lands in Texas.

4. Approach.

Energy balance and evapotranspiration calculations of a physically-based, dynamic simulation model will be validated using measurements of plant and soil energy balances at partial cover for a range of climatic regimes. Experiments will include measurement of instantaneous fluxes of latent heat from the crop and from the soil using a combination of Bowen ratio and stem flow measurements. Concurrently, a stochastic climate model (SCM) will be developed to produce daily weather data representative of current conditions for a range of climatic regimes and to produce daily weather data which represent expected climatic change as determined from general circulation models (GCMs). With SCMs, a large number of daily sequences of weather variables can be easily generated in contrast to GCMs. The SCM will allow effects of gradual climate change to be evaluated, which is more realistic than effects of equilibrium doubling of carbon dioxide associated with most studies of climatic change. These data will be used as inputs into the simulation model to evaluate ET and surface water balances over a wide range of current climatic regimes, as well as to evaluate how ET and water balances will be affected by climatic change.

ENGINEERING

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G2103
PROJECT TITLE:	The Role of Biosurfactants in Biodegradation of Hydrophobic Pollutants by Indigenous Microorganisms in Soil
PERFORMING ORGANIZATION:	North Carolina State University
PRINCIPAL INVESTIGATORS:	M. Aitken and C. Miller
DURATION:	August 1991 to July 1994

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

Polycyclic aromatic hydrocarbons (PAH) are among the most commonly found pollutants at contaminated subsurface sites. Bioremediation has been proposed as a viable method for treating soils and ground water contaminated with PAH. In situ approaches (as opposed to above ground treatment of excavated soil) are still in their infancy, and there is a generally poor understanding of the science of in situ biological activity and its relationship to fundamental physiochemical factors in the subsurface. In situ approaches are generally regarded as the most cost-effective option for remediation if they are technically feasible.

Even though bioremediation has been considered to be viable for sites contaminated with PAH, there are still issues associated with in situ bioremediation that remain unresolved. The extent to which the rate and extent of biodegradation is controlled by sorption within pores that are inaccessible to microorganisms has not been evaluated adequately.

2. Contribution to the Problem Solution.

The research will evaluate some of the fundamental factors involved in biodegradation of PAH sorbed to microporous solids. In particular, we will determine the role that microbial surfactants play in mobilizing these hydrophobic compounds from inaccessible surfaces. Knowledge gained from these studies then will be used to evaluate methods of stimulating PAH degradation, including degradation of a four-ring PAH. Results will be highly useful in developing improved techniques for in situ bioremediation.

3. Objectives.

The objective of this research is to evaluate the biodegradation of hydrophoblic pollutants whose rate of biodegradation is expected to be limited by their desorption from inaccessible pores in soil. The role of microbially produced surfactants in mobilizing and enhancing the degradation of compounds adsorbed to micro-pores will be investigated.

4. Approach.

Organisms that can degrade a model PAH will be isolated from soil contaminated with PAH and screened for surfactant production when grown to that compound. Those organisms found to produce extracelluar surfactants with the ability to reduce surface and interfacial tension to the greatest extent will be studied further. Effects of these surfactants on desorption of PAH from a model micro-porous solid will be studied; controlled pore glass beads containing uniform pores at sizes substantially smaller than bacteria will be used. Sorption rates and equilibria will be characterized for model PAHs in the presence and absence of biosurfactants. Effects of biosurfactants on biodegradation then will be evaluated. Finally, stimulation of surfactant production and its effect on biodegradation will be studied. Both a relatively degradable and a highly recalcitrant PAH will be investigated.

The use of surfactants to improve the mobilization and biodegradation of a sorbed pollutant has been proposed by several researchers. This research differs from other efforts in some key respects: (1) Others have studied the use of synthetic surfactants. Microbial surfactants are expected to be more biodegradable and less toxic than synthetics. (2) All other proposed and current research in this area has involved addition of exogenous surfactants. This research focuses on in situ production of surfactants. (3) Others have studied the only commercially available biosurfactant, emulsan, which does not reduce interfacial tension enough to enhance microbial uptake significantly. This project will focus on biosurfactants that reduce interfacial tension to substantially lower values than does emulsan. (4) In situ production of biosurfactants has been studied for tertiary oil recovery, which also has key differences from this work. First, organisms for tertiary oil recovery must be inoculated into the subsurface; we will focus on indigenous organisms. Second, anaerobic organisms are primarily used for enhanced oil recovery to preclude degradation of the petroleum under aerobic conditions; we will focus on aerobes because we are interested in stimulating biodegradation rather than

discouraging it. Third, many petroleum reserves are located in harsh environments (high temperature and salinity) that are unfavorable to non-indigenous organisms; again, we will focus on native organisms adapted to conditions at a contaminated site.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G2104
PROJECT TITLE:	Equilibrium and Kinetic Studies of Selective Organic Adsorption by Surfactant-Modified Clay
PERFORMING ORGANIZATION:	University of Delaware
PRINCIPAL INVESTIGATOR:	S. Dentel
DURATION:	August 1991 to July 1993

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

United States Environmental Protection Agency regulations being developed in implementing the 1986 Amendments to the Safe Drinking Water Act are requiring substantial improvement in water treatment technologies. Removal of certain organic substances must be to extremely low levels. Maximum Contaminant Levels (MCLs) have been established for 8 volatile organic chemicals and for 30 synthetic organic chemicals; a wide range of disinfectant by-products are also to be regulated. The MCL for benzene, for example is 5 µg/L with an MCL goal of 0 µg/L. Current technologies available for attaining these low concentrations remain expensive.

2. Contribution to the Problem Solution.

This research will investigate the use of surfactant-modified smectite clays (organo-clays) to selectively adsorb and remove certain of these organic contaminants from water. The clays are modified by insertion of the surfactant into the interlamellar spacings, creating a selective adsorption zone of adjustable dimensions and hydrophobicity, depending on the surfactant used and on the cation exchange capacity of the clay. By contrast, activated carbon, though exhibiting a high overall adsorption capacity, is relatively non-selective, and substantial adsorptive interference is observed in the complex chemical matrix of a surface water.

3. Objectives.

Two different smectite clays and a variety of surfactants will be employed in this research with the objective of maximizing selectivity toward the adsorption of the organic contaminant in the presence of innocuous, but competing, natural organic matter. It is in this competitive matrix, such as encountered in actual treatment of surface waters, that the advantages of preferential adsorption are most likely to be observed.

We will additionally evaluate kinetic aspects of the proposed application of organo-clays. Desorption of the surfactant pillars must be slow within the timeframe of the treatment process if the application is to be feasible for production of drinking water, and these desorption rates will be characterized for the surfactant-clay combinations. At the same time, adsorption of organic contaminants must be relatively rapid. Kinetic data for the adsorption process is necessary for proper process evaluation and design, and will also be obtained in a realistic multi-adsorbate matrix similar to a surface water.

4. Approach.

Equilibrium isotherm data will be generated by standard batch-test methods (closed, zero-head space) using analytical methods appropriate for the particular organic and concentration range in each experiment. Proper attention will be given to pH and ionic strength effects on both adsorption and analytical methods. Isotherms will also be produced in a system with background components simulating conditions encountered in water treatment. Stirred flow reactor experiments will be used in kinetic experiments.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G2105
PROJECT TITLE:	Management of Forested Filter Zones for Dispersion and Treatment of Agricultural Runoff
PERFORMING ORGANIZATION:	North Carolina State University
PRINCIPAL INVESTIGATOR:	E. Franklin
DURATION:	August 1991 to July 1994

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

The recent North Carolina Non-Point Source (NPS) Assessment (1989) showed that agriculture contributed 67 per cent of NPS pollution in problem streams and rivers and 60 per cent in problem estuaries. These percentages reflect regional trends. Most soil conservation practices remove water from agricultural fields efficiently and control erosion but do not affect the release of nutrients and toxic chemicals. Vegetative filter zones appear to be effective only if water is sufficiently dispersed. Forested filter zones which border agricultural fields offer great potential to operate as nutrient sinks if properly managed because of their stability and substantial structural resistance to erosion. However, on most farms, runoff flows through the filter zone in natural drainageways thus remaining concentrated and therefore rendering the filter zone ineffective.

2. Contribution to the Problem Solution.

Enhancement of the effectiveness of forested filter zones bordering fields offers the possibility for substantial improvement of the quality of surface water in the Southeast. Information from this research can be incorporated into recommended best management practices for farm forests and adjacent fields in the Southeast and used in designating the size of filter zones to protect valuable water resources.

3. Objectives.

The objectives of this research are to:

(a) develop a better understanding of the characteristics of forested filter zones and thus determine design criteria to retain and stabilize sediments and nutrients that degrade water resources; and

(b) demonstrate that dispersion of surface runoff can greatly improve the performance of forested filter zones.

4. Approach.

Whereas studies have demonstrated that forested filter zones can reduce the amount of nutrients and sediments reaching surface waters from agricultural fields, they have not examined whether filter zone effectiveness can be improved through dispersion of runoff. However, in a recently completed study, we demonstrated the feasibility of water quality improvement through dispersion of field runoff in the upper portion of the forested filter zone. Our approach will be to study two instrumented experimental watersheds for three years. Each watershed has a level spreader to distribute surface flow uniformly across the filter zone. Spreader design permits utilization of various proportions of the filter zone. An internal sampling plan will be used to examine the relationship between filter zone performance and factors such as slope, filter zone distance, microtopography, and vegetation characteristics. An irrigation system will be used to create standard runoff events and supplement data obtained from natural precipitation events. A model will be developed to describe the system's performance for use in filter zone design and management recommendations.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G2106

PROJECT TITLE: Non-Newtonian Enhancement of Both Stability and Permeability of Liquid Membranes for Detoxifying Wastewater

PERFORMING ORGANIZATION: Georgia Institute of Technology

PRINCIPAL INVESTIGATOR: A. Skelland

DURATION: August 1991 to July 1993

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

The detoxification of industrial wastewater by removal of a wide variety of contaminants, such as phenolic compounds, amines, ammonia, various metal ions, phosphates, chromates, nitrates, nitrites, and both organic and mineral acids, is a recurring and widespread problem.

2. Contribution to the Problem Solution.

Surfactant-stabilized emulsion liquid membrane processes constitute an emerging separation technology that has repeatedly been shown to be ideally suited for this purpose, because it is capable of removing such toxic substances down to very low levels. Unfortunately, all such processes remain seriously flawed by the current inability to develop a liquid membrane that exhibits a high level of stability without sacrifice in permeability.

3. Objectives.

The objective of this research is to investigate the use of additives to convert liquid membranes to suitable non-Newtonian form enhancing consistency without a sacrifice in permeability.

4. Approach.

To determine the effectiveness of the research solution to the problem, two complementary sets of runs will be performed in which globules of aqueous base, in oil emulsions, are dispersed in another agitated aqueous phase. The

first set will quantify the rate of transfer of phenol from agitated "wastewater", via a non-Newtonian oil membrane, to an aqueous base receptor phase. The second set will measure the non-Newtonian enhancement of membrane stability. The variables, selected partly from previous studies, will be non-Newtonian additive and surfactant concentrations, emulsifier type, wastewater/emulsion ratio, aqueous/oil ratio in the emulsion, and stirrer speed. So important is the attainment of stable membranes with unimpaired permeability to the future success of liquid membrane technology, that unabbreviated, factorially designed, experiments will be conducted to test the benefits of non-Newtonian conversion of the membrane.

GROUND-WATER FLOW AND TRANSPORT

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G2089

PROJECT TITLE: Volatilization of Organic Solutes

PERFORMING ORGANIZATION: Oklahoma State University

PRINCIPAL INVESTIGATOR: G. Brown

DURATION: August 1991 to July 1994

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

Many organic compounds, including many pesticides, solvents, and hazardous wastes, are both water soluble and volatile. When placed in the soil, they can be transported as a solute in the soil water and a vapor in the soil air. The relative importance and contribution of the vapor phase transport of volatile organic solutes is poorly understood, particularly when water is also being transported. A drying soil loses more of a volatile compound than a soil held at constant water content. This increase in volatilization can be attributed to liquid phase and soil-gas phase advection. Volatilization is further complicated by adsorption, phase equilibrium and phase transfer kinetics. Several models have been proposed to predict the transport or volatilization of organic solutes, but none have been rigorously tested, particularly with respect to transport in the vapor phase.

2. Contribution to the Problem Solution.

This research will determine the adequacy and suitability of existing models to predict volatilization of organic compounds to the atmosphere. Specific results will include better understanding of gaseous diffusion rates, sorption and phase equilibrium, and of the transfer resistance at the soil-atmosphere interface. These results will allow critical evaluation of the various processes and provide accurate measurements of transport and sorption parameters.

3. Objectives.

The overall objective of this project is to test the validity of existing models to predict volatilization of organic solutes to the atmosphere. The specific objectives of this research are to:

(a) measure equilibrium relationships and sorption kinetics for two volatile organic compounds in two soils by batch experiments and thin section chromatography;

(b) measure volatilization rates, and soil concentration profiles for the same chemicals and soils, using dynamic small column experiments;

(c) measure volatilization rates for a single soil and solute in a wind tunnel under varying conditions; and

(d) compare the experimental results to the empirical boundary layer model, to the transient transport model, and to other models if available.

4. Approach.

The general approach will be to measure the different transport coefficients separately, use those coefficients in the models, and then compare their predictions to observed complex flow experiments. The study will determine not only the amount volatilized, but also the distribution of solute within the soil profile. This will allow the volatilization rate to be compared to basic mass transport concepts. Batch experiments will be carried out to measure sorption equilibrium. Thin section chromatography will be used to measure sorption kinetics. Traditional column break-through and half-cell experiments will be performed for both saturated and unsaturated conditions to estimate solute diffusion, dispersion, and sorption. Transient, variable saturation, constant concentration boundary column tests will be performed for both small lab columns and large wind tunnel pans. Separation of liquid and vapor transport will be accomplished by performing tests at different gas phase pressures. Effects such as volatilization-driven gas convection, which cannot be measured directly, will be calculated from basic transport theory.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G2090
PROJECT TITLE:	Conditional Stochastic Modeling of Transport of Nonreactive and Reactive Contaminants in the Vadose Zone
PERFORMING ORGANIZATION:	University of Arizona
PRINCIPAL INVESTIGATOR:	T. Yeh
DURATION:	September 1991 to August 1993

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

Before establishing a new landfill site for waste disposal or assessing the impact of a contamination source on ground-water pollution, probable rates and paths of leachate migration through the vadose zone must be considered. The characteristics of leachate migration from the contaminant source are mainly determined by the hydraulic and geochemical properties of the geologic environment. These properties exhibit considerable spatial variations. Because only limited amounts of field data are available, there are uncertainties in the characterization of the hydraulic and geochemical properties and consequently in the prediction of the contaminant migration. Current hydrogeological practice commonly neglects spatial variability. Little research has been directed to address the effect of spatial variability in the vadose zone on uncertainty in the analysis of contaminant transport.

2. Contribution to the Problem Solution.

The research will thoroughly examine various aspects of this important issue by using a stochastic approach. In this study, we will investigate the effect of spatial variability of both hydraulic and geochemical properties in the unsaturated zone on the uncertainty in contaminant transport model predictions. We will develop sampling strategies for minimizing the uncertainties involved in unsaturated transport modeling.

3. Objectives.

The objectives of this research are to:

(a) develop conditional probabilistic predictions of nonreactive contaminant transport in heterogeneous unsaturated media from a limited set of sampling data;

(b) investigate the impact of the spatial variability of soil-solute chemical processes on reactive contaminant transport; and

(c) investigate the potential of the proposed conditional concept for designing sampling procedures that minimize the uncertainty in reactive and nonreactive contaminant transport predictions.

4. Approach.

Conditional simulation is a stochastic technique for making predictions with a limited amount of information. This technique has been widely applied to problems of flow and solute transport in aquifers; but it has not yet been employed in unsaturated transport modeling. Field experiments indicate that spatial variability has far more profound effects on moisture flow and solute transport in the vadose zone than in the saturated subsurface environments. The proposed method conditions the prediction with observed data and involves less restrictions than analytical or semi-analytical approaches. In conjunction with a spectral method random field generator, we will employ the Monte Carlo method and a two-dimensional unsaturated flow and transport model for the stochastic analysis. Unlike deterministic methods, the Monte Carlo technique ensures that the uncertainty in characterizing the governing physical and geochemical parameters is fully translated into the uncertainty of our model predictions.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G2091

PROJECT TITLE: Transport and Retention of Bacteria in Ground Water and In Situ Bioremediation of Organic Contaminants

PERFORMING ORGANIZATION: State University of New York at Buffalo

PRINCIPAL INVESTIGATOR: S. Taylor

DURATION: July 1991 to June 1994

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

In situ biological methods have promise as cost-effective, environmentally sound means of remediating hydrocarbon- and chlorinated hydrocarbon-contaminated ground water. While indigenous bacteria are capable of degrading many organic contaminants, it may be desirable to introduce into the ground water non-indigenous bacteria which have been better acclimated to the contaminants, either naturally or artificially. Also, significant resources are being expended to genetically enhance the degradative capabilities of bacteria to allow biodegradation of xenobiotic compounds. In both cases, the bacteria must be introduced into the ground water through wells or infiltration galleries. Presently, there is insufficient knowledge to quantitatively assess the transport of these bacteria once in the ground water, and therefore assess the feasibility or performance of biological remediation based on non-indigenous bacteria.

2. Contribution to the Problem Solution.

The fundamental contribution of this study is a quantitative understanding of the bacterial retention mechanisms in porous media, including bacterial adsorption to mineral surfaces and bacterial straining by unconsolidated porous media. Currently, both processes are only poorly understood and are known to govern transport of bacteria in groundwater. Results of this work will also lead to a comprehensive simulator of the in situ bioremedial process, which will be a useful design tool for assessing future biologically-based ground-water treatment systems.

3. Objectives.

The objectives of this research are to:

(a) quantify the retention of bacteria in porous media as a function of bacterial characteristics, flow characteristics, physical properties of the porous medium, clay and organic carbon contents of the medium, and the geochemistry of the groundwater;

(b) develop a predictive model of bacterial transport and retention, including the transport and utilization of an electron donor and an electron acceptor, for assessing the performance of in-situ bioremediation schemes using non-indigenous bacteria; and

(c) establish the environmental conditions, in terms of porous media characteristics and geochemistry, which are conducive to initiating in situ bioremediation of an aquifer using non-indigenous bacteria, and evaluate the feasibility of this process in an field application.

4. Approach.

Two primary experiments are proposed which will be complemented by theoretical analyses. The first set of experiments are designed to quantify the adsorption of specific bacterial strains in unconsolidated porous media as a function of the ground-water geochemistry, clay and organic carbon contents, and bacterial characteristics. In the second set of experiments, the rate of bacterial filtration will be determined as a function of flow and porous media characteristics. Mechanistically-based models of both adsorptive and straining processes will be developed for predictive purposes, and incorporated into a comprehensive model of the bioremediation process for assessing the feasibility of ground-water treatment based on non-indigenous bacteria. A two-dimensional formulation of this model will be used to simulate and design a bioremedial system at a field site in a test application.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G2092

PROJECT TITLE: Effect of Information Content on the Analysis of Transport in Strongly Nonuniform Geologic Media

PERFORMING ORGANIZATION: University of Arizona

PRINCIPAL INVESTIGATOR: S. Neuman

DURATION: September 1991 to August 1994

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

Ground-water contamination is an issue of national and global importance. As such contamination often takes place in complex geologic environments, an understanding of how plumes evolve in strongly nonuniform media is badly needed. To describe the extent of pollution at a given site, predict its possible future consequences, and investigate the potential utility of various remedial alternatives, field data must be collected to provide a realistic representation of site-specific conditions. How much data, of what kind and quality, where and when, must be obtained to gain a predetermined level of confidence in mathematical and computational analyses relevant to the above issues?

2. Contribution to the Problem Solution.

Development of a strategy to use and collect field data efficiently so as to achieve desired levels of uncertainty reduction, via conditioning, in the analysis of subsurface contamination problems with emphasis on strongly heterogeneous media would aid in the understanding and prediction of subsurface contaminant transport.

3. Objectives.

The overall objective of this research is to develop a strategy for the efficient use and collection of field data to achieve desired levels of reliability (uncertainty reduction) in the analysis of subsurface contamination problems in strongly nonuniform geologic media by means of stochastically derived deterministic transport equations.

4. Approach.

The project will examine the potential use of geostatistical and inverse methods to characterize and condition the velocity field on hydraulic test, as well as head and flux, data; use the new Eulerian-Lagrangian theory to calculate dispersive fluxes in space-time nonstationary velocity fields arising from such conditioning; incorporate these fluxes in transport calculations using appropriate differential and/or integro-differential equations; evaluate the associated estimation errors using Eulerian-Lagrangian expressions of their variance and autocovariance as given; and investigate the manner in which such estimation errors increase or diminish with a change in data quantity and quality. Both synthetically generated data and real field data will be used to investigate and demonstrate relevant aspects of the proposed strategy. Of special interest will be the question of how conditioning affects one's ability to model transport in strongly nonuniform geologic media to which existing stochastic theories of transport do not generally apply.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G2093
PROJECT TITLE:	Well-Testing Methodologies for Characterizing Heterogeneities in Alluvial-Aquifer Systems
PERFORMING ORGANIZATION:	University of Kansas
PRINCIPAL INVESTIGATOR:	J. Butler
DURATION:	August 1991 to July 1994

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

A considerable body of research has shown that large-scale spatial variations in hydraulic conductivity play an important role in controlling the movement of a contaminant plume in the subsurface. Unfortunately, the quantification of these spatial variations can be an extremely difficult task. Core analyses, single-well slug or flowmeter tests, and a variety of other methods have all been employed for this purpose. None of these approaches, however, are very effective for providing accurate estimates of the interwell variations in hydraulic conductivity, which are undoubtedly one of the primary determinants of plume movement. If predictive capabilities for subsurface transport are to improve, it is imperative that methodology that enables a more accurate characterization of the nature of interwell variations in hydraulic conductivity be developed. That is the purpose of the research described in this proposal.

2. Contribution to the Problem Solution.

This research will enable promising methodologies for the characterization of large-scale spatial variations in hydraulic conductivity to be thoroughly evaluated through both theoretical analyses and field experiments. The results of this evaluation will be an important contribution towards the development of a better understanding of the nature of conductivity variations in the subsurface as well as a cost-effective methodology for quantifying large-scale conductivity variations in the field.

3. Objectives.

The major objective of this research is to theoretically and experimentally evaluate the potential of promising well-testing methodologies for the characterization of spatial variations in hydraulic conductivity. The primary emphasis of the proposed research is on the assessment of multi-dimensional pulse testing for providing more accurate estimates of the lateral and vertical variations in hydraulic conductivity between wells in an alluvial aquifer. The ultimate goal of this work is the development of well-testing methodology that can significantly reduce the uncertainty associated with the characterization of large-scale spatial variations in hydraulic conductivity.

4. Approach.

This research will involve a considerable amount of theoretical development and field experimentation. The theoretical development will employ the analytical and numerical methodology commonly used in mathematical modeling with a strong emphasis on sensitivity analysis. The field component will involve the development and testing of new instrumentation and techniques at a research site developed by the Kansas Geological Survey. To the best of our knowledge, a thorough theoretical and field assessment of the potential of advanced well-testing methodology for the characterization of large-scale spatial variations in hydraulic conductivity has not been attempted.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G2157

PROJECT TITLE: Develop and Test Vulnerability and Toxicity Indices for Classifying Karst Aquifer Pollution Potential

PERFORMING ORGANIZATION: Pennsylvania State University

PRINCIPAL INVESTIGATOR: D. Kurtz

DURATION: September 1991 to September 1994

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

Protection of aquifers in the United States is critical because they are primary drinking water sources for a large portion of the population. Known quantities of nitrates and pesticides have resulted from farm and urban application in regions of the country. Unconfined karst aquifers are especially vulnerable to pollution from these sources. Karst aquifers are widespread throughout the United States and are important sources of groundwater in rural and urban areas. The vulnerability of important karst aquifers to pollution by farm and other chemicals must be more adequately defined.

2. Contribution to the Problem Solution.

The research will investigate water quality of springs on a monthly and runoff event basis for various known aquifer flow and recharge types in Nittany Valley, PA., to verify the utility of existing karst conceptual models that have been used to estimate the pollution potential of karst aquifers. In addition, the study will select subsets of karst aquifers with distinct flow and recharge types tapped by public water wells to compare their local water quality with season of the year and with runoff/recharge peaks reflected in major springs draining the same karst aquifer and ground water basin. The pesticides detected and their measured concentrations will be used to define an aquifer pollution vulnerability index that combines a knowledge of aquifer flow, recharge characteristics, and water quality as observed within springs and wells.

3. Objectives.

The objective of this research is to develop a "vulnerability index rating" and a "toxicity index" that will provide an effective means for determining the susceptibility of karst aquifers to pollution.

4. Approach.

This study will investigate water quality (mainly pesticides, nitrate-nitrogen, temperature and specific conductance) of springs on a monthly and runoff event basis for various known aquifer flow and recharge types in Nittany Valley, PA to verify the utility of a karst conceptual model that has been used to access the pollution potential of these aquifers. The recharge and flow conditions range from diffuse to conduit types with variable conditions in between these end members. In addition to three groundwater basins drained by springs, selected subsets of karst aquifers located in these same drainage basins will be studied for pollution potential using domestic and high capacity wells. These will be sampled monthly and on an event basis at the same time as the springs are sampled over a two year period.

Pesticides detected, their measured concentrations, and their known oral toxicities will be used to define an aquifer pollution vulnerability and toxicity index that combines a knowledge of aquifer flow and recharge characteristics, the number of the compounds detected, their concentration, and frequency of occurrence. In basin areas dominated by conduit-recharge and conduit-flow, vulnerability ratings will be used to compare springs with wells as sampling sources representative of the water source vulnerability. In areas of diffuse recharge and/or diffuse flow dominated basins, vulnerability ratings will be used to show the variety of conditions under which sampling measurements must be made in order to assess vulnerability.

Toxicity ratings developed here will be used to identify portions of watersheds that supply unique chemicals to wells and springs in order to delineate well head protection areas for wells and springs and pollution threats to future water supply sources.

SOCIAL SCIENCES

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G2082
PROJECT TITLE:	Agricultural Practices and Ground-water Quality in the High Plains: Impact of State, Regional, and National Policies
PERFORMING ORGANIZATION:	Oklahoma State University
PRINCIPAL INVESTIGATOR:	H. Mapp
DURATION:	August 1991 to August 1993

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

Public concern over ground-water quality has grown significantly. In recent years, agriculture has been identified as one of the most pervasive contributors to nonpoint-source pollution of surface water and ground water. Policies aimed at controlling sources of agricultural pollution will serve as important determinants of production practices and technologies employed in the High Plains region, as well as influence the profitability and sustainability of irrigated agricultural production. Although significant ground-water quality policy is being discussed at the state and national levels, little research has been conducted to assess the economic impacts of alternative policies.

2. Contribution to the Problem Solution.

This project will provide estimates of the economic and ground-water quality impacts of various possible potential national, state, and regional water quality policies. The approach will integrate information on the policy options with current agricultural practices, including crop, soil, tillage, chemical use, and irrigation practices to determine the economic impacts of alternative water quality policies. Accurate estimates of the policy impacts of national, state, and regional policy alternatives are essential information for policy makers involved in the development of ground-water quality legislation, guidelines, or recommendations.

3. Objectives.

The objectives of this research are to:

(a) divide the area overlying the High Plains aquifer into unique agricultural subregions, and identify crop and chemical use alternatives, tillage and irrigation practices, and aquifer characteristics needed to represent the diverse agricultural production practices used in each subregion;

(b) identify state, regional, and national institutional factors and agricultural water-quality policy alternatives designed to modify production practices and reduce the likelihood of ground-water quality degradation;

(c) construct a series of models to establish the relationships between agricultural practices and chemical movement, and project the rates of adoption of alternative production practices under each policy option;

(d) estimate the potential environmental and economic impacts of the policy alternatives, including changes in chemical use, movement of nitrogen and agrochemicals in percolation and runoff, changes in regional and national production, commodity price impacts, and changes in producer incomes; and

(e) develop and disseminate information to policy makers, farmers, and other interested groups regarding the impacts of policy alternatives and production practices which will maintain ground-water quality in the region.

4. Approach.

Several models will be constructed to establish the relationships between agricultural practices and chemical movement, and to project the rates of adoption of different tillage and irrigation practices under the alternative policy options. A chemical transport model will predict movement of nitrates and specific pesticides in runoff, sediment, and percolation throughout the soil profile. A mathematical programming model of the agricultural sector overlying the High Plains aquifer will estimate the economic impacts of the alternative national, state, and regional water quality policies. Changes in regional production will be used in a national agricultural sector model to determine changes in national commodity prices and regional prices and incomes. A

ground-water flow model will be used to estimate declines in the water table in the High Plains aquifer. The research methods are quite innovative, and provide an approach which could be used in subsequent regional analyses focusing on the economic impacts of national, state and/or regional water quality polices.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G2083

PROJECT TITLE: Agricultural Ground-water Contamination and Land Values: Theory and Application

PERFORMING ORGANIZATION: University of Maryland

PRINCIPAL INVESTIGATOR: E. Lichtenberg

DURATION: September 1991 to August 1992

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

Contamination of ground-water supplies is a growing cause of concern throughout the United States (U.S.). As rural land has been converted to residential use, reliance on ground water has grown and contamination episodes have become more widespread. Agricultural practices have been targeted as a key contributor to ground-water contamination problems. A recent report issued by the U.S. Department of Agriculture notes that agricultural chemicals have been documented as a key source of ground-water contamination in a number of States across the U.S. Nitrate from chemical fertilizers and animal wastes is one of the most frequently documented contaminants of ground water and 34 States have reported these sources as a major cause of ground-water pollution. According to U.S. Geological Survey data, 6 percent of rural wells have nitrate levels exceeding the Environmental Protection Agency interium drinking water standard of 10 parts per million. Adverse health effects from exposure to high nitrate levels include methemoglobinemia in bottle-fed infants and increased risk from gastric cancer.

The rapid pace of conversion of farmland to residential use has made the ground-water pollution problem especially severe. As more people become dependent on ground-water supplies in former agricultural areas, more are exposed to nitrate contamination. Because there is often a considerable time lag between initial leaching from the crop root zone and the arrival of nitrate in aquifers used for drinking water, current contamination is a function of agricultural practices of years past. Since nitrogen applications have been increasing until recently, ground-water pollution may well increase.

2. Contribution to the Problem Solution.

No studies have been conducted of the problems associated with agricultural ground-water pollution on the urban-rural fringe or on the effects of this contamination on land markets. The econometric answers from the hedonic price study will determine what sorts of policy solutions the economist may suggest. If nitrates do affect property values, then market incentives can be used to address the problem of nitrate contamination. Under such conditions, policy measures such as requiring a well test before selling can be quite useful.

3. Objectives.

The objectives of this research are to:

(a) develop a theoretical methodology for examining the dynamics of, and private disincentives for, agricultural ground-water contamination;

(b) derive from the analytical model a set of qualitative guides prescribing the types of data and geographic locations for the empirical study;

(c) conduct a hedonic price study to determine the relationship between agricultural ground-water contamination and development land values in Maryland; and

(d) conduct a survey to examine individual households attitudes and decisions regarding groundwater quality and home ownership in urban-rural fringe development areas.

4. Approach.

The research will model ground-water contamination problems, both conceptually and empirically, in areas of rapid residential development with an emphasis on the functioning of the land market. On a conceptual level, we will analyze imperfections in the ability of the land market to take into account ground-water contamination and the likely effects of alternative policies for addressing ground-water contamination problems. On an empirical level, we will analyze the impact of recognized ground-water contamination on the price of farmland being developed for residential uses in Maryland. Maryland provides an especially good context for such an empirical study. Over the past 15 years, the State has been characterized by rapid urbanization and conversion of rural land to residential uses. It is especially susceptible to ground-water contamination and has one of the highest nitrate contamination rates on the East Coast. Both the hedonic and survey methods will be employed to discover if this relationship exists.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G2084
PROJECT TITLE:	Regional Modeling and Economic Incentives for Water Quality and Quantity Control
PERFORMING ORGANIZATION:	University of California at Davis
PRINCIPAL INVESTIGATOR:	R. Howitt
DURATION:	August 1991 to August 1993

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

Irrigated agriculture is a major user of scarce water and has been associated with water quality problems as well. Agricultural drainage waters are an example of non-point pollution that includes salts, pesticides, nitrates, selenium, and other trace elements which pollute soils, surface-water bodies, and aquifers. This pollution directly and indirectly affects agricultural productivity, wildlife, and public health. In addition to the quality aspects, the increasing competition for water among urban, industrial, environmental, and agricultural users in western and southwestern United States has led policy makers to consider improved irrigation practices as a source of water conservation. Water conservation in irrigated agriculture has been suggested as an efficient way to achieve the dual goal of saving fresh water supplies and improving environmental quality. Therefore, it is important to identify appropriate irrigation technologies and determine a system of incentives needed for agricultural users to adopt them.

There are several types of difficulties associated with identifying solutions to this problem. One issue is associated with the complexity of modeling physical and biological systems including both spatial and dynamic aspects, and their relationships to economic decision making. Another issue is that solutions must be based not only on technical and engineering efficiency but also on economic efficiency and on acceptability to all parties involved.

2. Contribution to the Problem Solution.

At this stage, after the five year effort of the San Joaquin Valley Drainage Program, there is enough technical and empirical data on agricultural water pollution to conduct policy oriented research focusing on new aspects,

such as regional cooperation and implementation of suggested policies. This research will contribute to solving problems of water quantity and quality associated with agriculture by developing a regional approach to optimal water use and cooperation. Using this approach, alternative irrigation technologies and regional water-quality treatment facilities will be evaluated to identify those which are economically efficient, both in terms of the individual producers and the region. A test of the acceptability of efficient solutions in a real world setting will contribute to understanding possible obstacles in application of policies aimed at solving water quantity and quality problems.

3. Objectives.

The objectives are to develop and demonstrate a regional water quality/ quantity modeling system which includes the effects of individual water- use decisions, both spatially and over time, and the resulting pollution accumulation.

4. Approach.

The study will use an a geographic region as a basis for agricultural and economic components for modelling. First, a regional model of agricultural water use and drainage water quality will be developed by integrating physical, biological and agronomic models for the region with an economic decision making model. Second, water-use technologies for irrigation, water treatment, and other farming practices will be identified which are economically efficient in terms of meeting water quantity and quality constraints, including the demand for water by competing sector. Efficiency of technical solutions will be related to constraints on water quality and quantity as determined by urban and environmental interests. Third, we will identify incentives and cost sharing schemes required for adoption of appropriate technologies and acceptability of institutions, both at an individual farmer and regional levels.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G2085

PROJECT TITLE: Effect of Agricultural Practices on Surface-Water Quality

PERFORMING ORGANIZATION: Purdue Research Foundation

PRINCIPAL INVESTIGATORS: J. Lee and R. Lacewell

DURATION: August 1991 to August 1993

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

The major off-site cost of soil erosion in the United States relates to its impact on surface-water quality. Sediment from cropland decreases water-storage capacity in lakes and reservoirs, increases dredging costs, clogs streams and drainage channels, increases the treatment cost of potable water, and reduces the value of water for recreational uses. The damage to surface-water quality due to sediment from agricultural cropland has been estimated at 2.2 billion dollars per year. While less information is known about the costs of pesticide and nutrient loading to surface waters, many observers suggest that there are significant impacts and costs. Selection of an appropriate management strategy or policy aimed at improving surface-water quality must consider reductions in sediment as well as pesticides and nutrients from agricultural lands. However, the scientific literature is unclear about the relationship. Policy-makers should be informed about both the environmental effectiveness and economic impact of alternative policies.

2. Contribution to the Problem Solution.

The purpose of this project is to establish a framework to assess the economic and environmental impacts of alternative policies aimed at improving surface-water quality. Specifically, this research will examine the impacts of alternative land use and agricultural policies on the surface-water quality of the White River drainage basin in central Indiana. Once developed, this research framework can be extended to other regions or the nation as a whole.

3. Objectives.

The objectives of this research are to:

(a) estimate the economic returns and soil erosion effects under stochastic weather conditions for different crops, production practices and soils found within White River basin;

(b) determine the economic and water-quality impact of a conservation compliance provision;

(c) assess how changes in selected agricultural policy alternatives affect water quality levels of the river as well as the distributional impacts that these policies could have on crop production and income in the region; and

(d) develop a graphically based system which policy makers can use to interpret relevant economic and water-quality parameter estimates from the various models.

4. Approach.

To accomplish the objectives, three simulation models and a regional programming optimization model will be used to evaluate the economic and environmental effects of different policy scenarios. The first simulation model consists of the application of a daily crop growth model known as Erosion Productivity Impact Calculator (EPIC). EPIC will be used to generate distributions of crop yields and soil erosion, and runoff for various locations and production practices within the basin (under stochastic weather conditions). It is necessary to simulate different crop production practices to account for changes in water quality due to adjustments in crop production caused by changes in agricultural or environmental policies. Distributions of net returns by cropping system will be developed based on crop budgeting analysis, simulated yields from EPIC, and synthesis of crop price projections from several national policy studies. The net return distributions will provide input into a regional quadratic programming model of the White River basin to predict optimal cropping patterns under different policy scenarios. Results from the programming model will provide input into a basin scale water-quality simulation model known as Simulator for Water Resources in Rural Basin: Water Quality (SWRRBWQ) (Arnold, et al., 1990a). SWRRBWQ is capable of simulating sediment movement, nutrient runoff, and pesticide transport to surface waters in a large hydrologic basin under stochastic weather conditions.

The third simulation model used in this project is the National Water Quality Model (NWQM). Output from SWRRBWQ on agricultural based nonpoint source pollution will be combined with information on point source pollution in NWQM to estimate the water quality impacts of different agricultural and environmental policies.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G2086
PROJECT TITLE:	Marginal Cost Pricing Rules for Demand Behavior, System Net Benefits, and Water Utility Financing
PERFORMING ORGANIZATION:	Planning and Management Consultants
PRINCIPAL INVESTIGATOR:	T. Feather
DURATION:	August 1991 to June 1993

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

Pricing is possibly the most important tool available for use in improving the efficiency of water use and achieving water conservation. Economic theory shows that prices based on relevant marginal costs tend to maximize system net benefits to the extent that use is sensitive to price. The literature reveals only a handful of references to techniques for measuring the marginal costs of water supply, to actual marginal cost studies, or to measuring the losses of net benefits from using other pricing rules. There is a need to develop sound and practical measurement techniques and to provide the results of marginal costs studies for use as benchmarks by others.

2. Contribution to the Problem Solution.

The availability of a coherent, complete, and reproducible set of methods for estimation of marginal costs suitable for water supply, and of representative results of their application, would support the development of efficient pricing systems and rational criteria for choosing conservation measures, and would provide a benchmark for the use of system managers.

3. Objectives.

The objectives of this research are to:

(a) review and clarify existing concepts of marginal cost, especially the Turvey concept and that which is implicit in system expansion modeling;

(b) estimate these alternative concepts of marginal cost for two major water utilities;

(c) identify the major factors that influence the resultant patterns of marginal cost; and

(d) examine the implications of pricing according to these alternative measures of marginal cost for demand behavior, system expansion, utility financing, and the generation of system net benefits.

4. Approach.

The proposed study consists of four major tasks:

1. Definition of marginal cost. The concepts of marginal cost described in the literature will be restated and compared to the concepts based on a dynamic capacity expansion model.

2. Data collection and evaluation. The necessary data will be collected on-site for each of the two utilities including estimates of cost of future expansions.

3. Preparation of marginal cost estimates. Using the collected data and the above definitions, the system model and marginal costs will be estimated and carefully documented for each utility.

4. Analysis of demand behavior and utility financing. The results produced in previous tasks will be examined for implications for demand behavior and utility financing.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G2087
PROJECT TITLE:	An Investigation Into the Literature Used by the Water Resources Research Community
PERFORMING ORGANIZATION:	University of Wisconsin
PRINCIPAL INVESTIGATOR:	R. Walker
DURATION:	August 1991 to July 1993

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

The importance of literature in the area of water resources has long been known, first by the Office of Water Resources Research and later by the Office of Water Research Technology, and now by the U.S. Geological Survey, and each agency in turn has promoted its use through increased availability and accessibility. The need for technical information extends beyond the requirements of scientists and engineers, to a responsibility to disseminate information to a broader spectrum of potential users. There are special problems with water resources information. Much of the research is multi-disciplinary and the literature produced by such research is dispersed among widely differing disciplines, making it difficult to identify, acquire, use or even fully appreciate.

2. Contribution to the Problem Solution.

This project will allow sponsors of research to better understand how information is best produced and disseminated to facilitate its wider use. It will also identify the important literature of the past to assist in the determination of needed research areas and help justify the support of research in water resources and related fields.

3. Objectives.

The objectives of this research are to:

(a) determine overall use of Federally supported research in water resources;

(b) identify specific sources of cited literature;

(c) determine the format of literature cited by water resources researchers; and

(d) establish the age and rate of obsolescence of the literature of research reported in water resources.

4. Approach.

This project addresses the availability and use of water resources literature produced by Federal government-sponsored research in general and by the Water Resources Research Institute Program in particular. It involves the identification of the literature used by the water resources community as it is cited in the research literature of that field. It will attempt to identify where the cited research literature was published, who sponsored the research, in which communication forms it appeared, and to which subject fields within water resources it belonged.

This project will employ a technique known as citation analysis, a bibliometric method, to determine what literature is used by a group of researchers or other writers. A sample of the reported research in journal articles, technical reports, and conference papers will be drawn to create a corpus of the cited literature to be analyzed as to sponsorship, form of publication, age, publisher type, and area of research (field or discipline).

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G2088
PROJECT TITLE:	Identifying Options to Address Public Preferences for Watershed Management to Enhance Water Quality
PERFORMING ORGANIZATION:	University of Rhode Island
PRINCIPAL INVESTIGATOR:	S. Swallow
DURATION:	August 1991 to August 1993

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

To achieve water-quality objectives, comprehensive management planning at the watershed scale inevitably raises conflicting impacts. That is, each management option may affect several water-related resources as well as many users of water-related resources simultaneously. However, existing economic methods treat each resource use separately and do not account explicitly for simultaneous impacts on several resources and resource uses.

2. Contribution to the Problem Solution.

This project will contribute by developing and testing an economic methodology for evaluating the bundle of resource services affected by watershed management options. The project will demonstrate a means for evaluating interdependent, market, and non-market benefits of management for water-quality objectives and will improve water-resources planners' understanding of the multifaceted tradeoffs which the relevant public prefers.

3. Objectives.

The objectives of this research are to:

(a) develop a comprehensive and practical methodology for identifying watershed management options consistent with public preferences. The project will extend economic methods in order to improve evaluation of the bundle of resources impacts associated with watershed management options;

(b) test the methodology on an actual watershed management problem. The project will implement the methodology for a major watershed within the Narragansett Bay watershed; and

(c) evaluate the importance of resource use interactions in assisting planners to identify the socially preferred management option.

4. Approach.

The project will extend the contingent valuation method (CVM) for estimating the benefits of non-market goods. The project will use CVM's Paired Comparison method to simulate actual policy decisions; this method presents respondents with two specially designed management options, and econometrically uses their discrete choices to identify preferred tradeoffs and rank options. The approach supports conventional cost-benefit analyses while incorporating interdependent tradeoffs important to resource users.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G2149

PROJECT TITLE: Land Users' Economic Responses to Ground-water Protection Policies and Their Impact on Water Quality

PERFORMING ORGANIZATION: University of Massachusetts

PRINCIPAL INVESTIGATOR: C. Harper

DURATION: September 1991 to August 1993

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

Protection of ground-water quality has been identified as an urgent national priority. Numerous regulatory and non-regulatory protection strategies are being used, including zoning restrictions, chemical bans, best management practices and economic incentives. Little is known, however, about how effective any of these policy measures will be. There is little empirical evidence about how individual land users will respond to each type of public policy, and how these responses will in turn affect water quality.

2. Contribution to the Problem Solution.

This research will model the effectiveness of various public policy measures for ground-water protection. The model consists of two components, one socioeconomic and the other hydrogeological. The economic model describes how land owners and land users respond to various public policy measures. This individual economic choice will vary with the type of policy enacted, the type of land use in which the individual is engaged, and the physical characteristics of the land. Behavioral responses may include adjusting the level of use of chemical input, changing to a different input or management practice, or converting land to another major land use category. The hydrogeological model in turn studies empirically the effects of these behavioral responses on ground-water quality.

3. Objectives.

The objective of the project is to quantify the effectiveness of alternative public polices for ground-water protection, taking into account the central role played by the economic choices of individual land users.

4. Approach.

The approach is to integrate an empirical economic model of individual choices in response to governmental ground-water protection policies with an empirical physical model of the impact of human land use practices on the observed levels of ground-water contaminants such as nitrate, sodium, volatile organic carbons, and pesticides. The large, cross-sectional data set will include land uses, site characteristics, and water quality variables for several hundred public water supplies in Massachusetts. Data are represented spatially and integrated within a Geographical Information System. No previous empirical model has integrated the economic and physical aspects of ground-water protection in this way. The economic model will permit an evaluation of economic costs as well as social benefits from alternative policy measures, where social benefits are in the form of reduced probability of contamination.

WATER QUALITY

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G2094
PROJECT TITLE:	Enhancement of Photodegradation of Pesticides in Soil by Transport Upward in Evaporating Water
PERFORMING ORGANIZATION:	University of Nevada
PRINCIPAL INVESTIGATOR:	G. Miller
DURATION:	September 1991 to August 1994

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

Pesticide contamination of surface and ground water is related to movement and transformation processes that occur at the air/soil interface. This fraction of the soil column has properties distinctly different from those of the bulk soil, since it experiences large variations in temperature due to solar heating, is generally in a higher oxidation state due to the production of photochemical oxidants, and is the fraction of soil most likely to erode. It is also the fraction of soil that receives direct application of surface applied pesticides, and is the location at which pesticides will concentrate when brought to the surface with upwelling water. In the absence of degradation mechanisms, carry-over of pesticides from year to year can cause significant damage to rotated crops, and result in decreased agricultural yields. Water soluble compounds may also contribute to non-point source pollution via runoff and agricultural drains.

2. Contribution to the Problem Solution.

The importance of phototransformation processes in this fraction of the soil column has been substantially underestimated, particularly for those chemicals that move with evaporating water. Although photolysis occurs only in the top 100-500 μm of soil, chemicals that are transported in water can move to the surface and be exposed to both direct and indirect photochemical processes. For water soluble compounds, photolysis on soils is likely to be a significant transformation pathway. Information on rates of transport and subsequent photodegradation will provide estimates of pesticide field-residence times and potential runoff/drain burdens which will assist in agricultural planning.

3. Objectives.

The objectives of this research are to:

(a) assess the enhancement of photodegradation of three water soluble pesticides under various levels of soil water flow driven by evaporation of soil water;

(b) determine the significance of specific soil and environmental variables which affect the movement of the three photolabile pesticides (pentachlorophenol, napropamide and imazaquin) from the soil profile upwards into the photic zone; and

(c) provide estimates of the rates of photolysis of these types of pesticides under a range of soil and water flow conditions.

4. Approach.

This research will examine the rate of photolysis of three pesticides in soils of differing texture and organic matter content under the influence of evaporating soil water to evaluate the impact of transport of water soluble compounds on photodegradation at the soil surface. The soils will be irradiated both with outdoor sunlight and under artificial light banks, where variables such as temperature, air flow, and length of light exposure can be controlled. The pesticides chosen, pentachlorophenol, napropamide and imazaquin, have low volatility and high water solubility, and can be expected to be transported to the soil surface by capillarity in evaporating water. The pesticides will be either surface applied and watered in, with regular applications of water to simulate rainfall or irrigation; or will be incorporated into the bulk soil and subjected to constant saturated and/or unsaturated flow regimes. The rates of upward transport and photolysis can then be calculated for a variety of environmental conditions (water content, evaporation rate, sunlight intensity, soil characteristics, air temperature, and wind speed).

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G2095
PROJECT TITLE:	Rates and Mechanisms of Chemical Recovery from Acidification in Little Rock Lake, Wisconsin
PERFORMING ORGANIZATION:	University of Minnesota
PRINCIPAL INVESTIGATOR:	P. Brezonik
DURATION:	August 1991 to July 1994

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

Neutral pH conditions in acidified lakes can be restored rapidly by liming, but this is not a practical solution for the more than one thousand acidic lakes identified in the United States (U.S.) by Environmental Protection Agency surveys. Control of sulfur dioxide emissions by the recently enacted Clean Air Act will lead to lower rates of acid deposition over wide areas of the U.S., and this ultimately will promote a natural return to chemically neutral conditions in acidic lakes. However, response times of lakes are poorly understood, and the relative importance of various in-lake mechanisms of acid neutralization compared with watershed neutralization processes are not known. Consequently, scientists cannot predict recovery rates, and the design of programs to monitor the effectiveness of emission controls is inefficient at best. Because studies of recovery from acid stress have not been done, information is lacking on the completeness of chemical and biological recovery once a lake's pH and alkalinity return to its pre-acidified state, and the extent to which chemical and biological recovery lags behind acid neutralization is unknown.

2. Contribution to the Problem Solution.

By determining rates of chemical recovery in Little Rock Lake (LRL), which was acidified in a six-year controlled experiment, the research will evaluate the effectiveness of in-lake processes of acid-neutralization, determine the completeness of chemical recovery (and extent of lags), and develop a model that can be used to predict chemical recovery rates for other acidic lakes.

3. Objectives.

The objectives of this research are to:

(a) determine the rates of pH and alkalinity recovery of LRL from a controlled acidification to pH 4.7 and rates of recovery of other chemical conditions;

(b) evaluate the mechanisms controlling the rate of chemical recovery and factors affecting those mechanisms; and

(c) develop a model or framework from which recovery rates of other lakes can be predicted.

4. Approach.

The lake will be sampled monthly during the first three years of recovery (post-acid loading, beginning in spring 1991), and complete chemical analyses will be done. Mechanisms of in-lake alkalinity generation will be evaluated from profiles of porewater chemistry and ion budgets (especially for sulfate and base cations). A reactor-based model will be modified to account for alkalinity generation by in-lake mechanisms and groundwater flow.

PROJECT INFORMATION

GRANT NUMBER:	14-08-0001-G2096
PROJECT TITLE:	Ionic Binding and Its Effect on the Conformation and Sorptivity of Natural Organic Matter
PERFORMING ORGANIZATION:	Oregon Graduate Institute of Science and Technology
PRINCIPAL INVESTIGATOR:	W. Fish
DURATION:	September 1991 to August 1994

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

The humic substances found in soils and natural waters alter the solubility, transport, and availability of contaminants such as pesticides and heavy metals. Advances have been made in describing the influences of humic substances on metal chemistry and on the partitioning of hydrophobic organic compounds, but it is not yet possible to predict the behavior of humic materials in environments with highly dynamic chemical composition. In these environments, such as estuaries or complex subsurface contamination sites, humic materials may be exposed to wide ranges of ionic strength, pH, and ionic composition. These variable solution characteristics alter the size, conformation, charge, solubility, and hydrophobicity of humic substances and therefore change their tendency to bind to contaminants. Accurate assessment and modeling of pollutants in critical hydrologic systems such as estuaries and aquifers requires more exact knowledge of the relationships among solution composition, humic properties, and humate-contaminant binding.

2. Contribution to the Problem Solution.

This research integrates two areas of humic research that hitherto have been largely unconnected: cation-humate interactions and the partitioning of hydrophobic compounds into natural organic matter. The coordinated study of inorganic and organic associations with humic matter will reveal the strengths and weaknesses of current approaches, will improve the understanding of the

basic physical chemistry of contaminant sorption, and will yield improved methods for estimating contaminant partitioning in dynamic natural environments.

3. Objectives.

The objectives of this research are to:

(a) thoroughly quantify the changes in the size, conformation, electrostatic charge density, and hydrophobicity of specifically selected, well defined humic substances in response to systematic changes in solution pH, ionic strength, and ionic compounds;

(b) predict the direction and magnitude of changes in the calculated organic-matter partition coefficients of selected pesticides in response to solution-induced changes in humic properties; and

(c) test the hypothesis that current methods of predicting the partitioning of hydrophobic contaminants can be made more accurate and more generally applicable by inclusion of a rigorous handling of cation-humate associations and the concomitant changes in humic molecular configuration.

4. Approach.

Carefully controlled laboratory experiments will be conducted, using well characterized reference humic substances. For cation-humate association studies, conventional titration methods will be coupled with in situ spectroscopic methods so that macroscopic chemical properties can be directly related to molecular-scale properties. Organic partitioning experiments will be closely linked to specific cation-binding experiments using a consistent set of conditions and experimental materials. This approach will provide more conclusive results than can be deduced from piecemeal evidence in the literature.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G2097

PROJECT TITLE: Development of a Remote Sensor for Metal Ions in Subsurface Water

PERFORMING ORGANIZATION: University of Wyoming

PRINCIPAL INVESTIGATOR: K. Carron

DURATION: August 1991 to July 1993

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

Current methods for monitoring ground-water contaminants require removal of a sample from the contaminated site. This presents several problems. First, in the case of ground water the composition of the sample can change drastically on exposure to air. In particular, oxidation states of metals can change upon exposure to air. Furthermore, the equipment used to bring the sample to the surface can inherently contaminate the sample or through repeated use and insufficient cleaning lead to false concentrations. The removal of contaminated water from wells also causes depletion of contaminants and can lead to false determinations. This can be especially troublesome with metal ions which tend to move with partitioning rather than advection. Finally, if the site contains highly toxic materials, exposure to personnel can be a problem with the current methods of sample removal.

2. Contribution to the Problem Solution.

This research will alleviate the problem through a remote sensor which measures metal ion concentrations in-situ. This will allow more accurate determination of metal ion concentrations and avoid exposure risks to personnel.

3. Objectives.

The objective of this research is to develop a remote sensor based on optical fibers and Raman spectroscopy. The ultimate goal of this project is to construct a field compatible sensor which is both ultrasensitive and selective toward a given metal ion.

4. Approach.

A feasibility study to test the practical benefits of a Raman based fiber optic probe has been conducted. The study showed that Raman spectra of certain indicator molecules can be obtained with high sensitivity and that the spectra change in a predictable fashion depending on the metal ion present. This research will continue with the development of robust sensors which are not affected by conditions which may be present in ground water. Recently developed anticorrosion agents will provide protection to the sensor and will be used to anchor the chemical indicators which are used in the metal ion sensing. An inexpensive, sensitive Raman detection system will be constructed. This system will be based on a multichannel spectrometer and on either diode lasers or air-cooled ion lasers. The multichannel detection will permit subtraction spectra to be obtained and an internal standard approach to be used to quantify the metal ion concentration. The internal standard alleviates all of the serious problems which are associated with the measurement of absolute intensities to determine metal ion concentrations.

PROJECT INFORMATION

GRANT NUMBER: 14-08-0001-G2150

PROJECT TITLE: Organic Solvent Effects on Colloid Mobilization

PERFORMING ORGANIZATION: Michigan State University

PRINCIPAL INVESTIGATOR: S. Anderson

DURATION: September 1991 to September 1994

PROJECT DESCRIPTION

1. Identification of the Water-Related Problems.

Organic and inorganic colloids can enhance the mobility of hydrophobic organic pollutants, actinide species, and trace metals. To predict colloid-enhanced transport, and ultimately to prevent aquifer contamination by colloid-bound pollutants, an understanding of how the compositions of both the mobile solution and the stationary solid phases effect colloid detachment and mobility is essential. At present, little is known of how colloid release and mobility is affected by the presence of organic solvents. Both water-miscible organic "cosolvents", such as may be present with radioactive wastes, and water-insoluble organic liquids that move as a separate nonaqueous phase (for example, hydrocarbon fuels) may facilitate the mobilization of colloids and their subsequent transport.

2. Contribution to the Problem Solution.

This research will provide valuable information about the chemical processes involved in organic-solvent-induced colloid dispersion. Persons who develop and test solute transport models will be able to utilize information concerning the effects of organic solvents on colloid-enhanced transport. In addition, engineers who develop aquifer pumping plans for containment of contaminant plumes may need to recognize that the leading edge of a contaminant plume might move faster when cosolvents and additional colloids are present.

3. Objectives.

The objectives of this research are to:

(a) quantify the effect of organic solvents on the mass and composition of colloids released (detached) from clay-oxide-humic acid aggregates;

(b) measure the effect of organic solvents on the rate of colloid detachment;

(c) evaluate the relationship between aggregate composition and organic solvent effects on colloid detachment from clay-oxide-humic acid aggregates; and

(d) evaluate the relationship between colloid composition and the magnitude of organic solvent effects on the electrophoretic mobility of mixed clay-oxide-humic acid colloids.

4. Approach.

Each of the research objectives focuses upon the chemical causes of colloidal detachment. A bulk aggregate-immersion procedure, similar to that developed to quantify the effect of aqueous solution composition on the dispersive behavior of soil clays, will be used to measure the mass of colloids dispersed or suspended when aggregates are immersed in aqueous, organic, or mixed-solvent solutions for time periods of up to one week. The static aggregate-immersion method allows isolation of colloid detachment processes from the competing processes of colloid filtration and immobilization, which would complicate column experiments. Data may be obtained for a large number of samples with a relatively small investment of capital and time. By careful choice of the total solid mass, the total colloid yield will be sufficient for chemical analyses of the released colloids.

Four organic solvents (ethanol, pyridine, acetone, and n-octane) will be mixed with a dilute aqueous $CaCl_2$-KCL solution at pH 7. Aggregates comprising known amounts of illite, iron oxides, and humic acid will be equilibrated with each solvent mixture. The clay, Fe, and C concentrations of colloidal material released during a 1-week equilibration will be measured. We also shall determine the effect of the above four organic solvents upon particle electrophoretic mobilities, using the moving boundary method. Electrophoretic mobilities will provide valuable information about the influence of an electric field, such as that created by charged, stationary, particles in porous media, on the mobility of particles suspended in different solutions.

SECTION II

SUMMARIES OF PROJECTS COMPLETED

IN FISCAL YEAR 1991

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1147

PROJECT TITLE: Hydrology and Sedimentology Model for a Dynamic Rill Network

PERFORMING ORGANIZATION: University of Kentucky

PRINCIPAL INVESTIGATOR: B. J. Barfield

START: September 1985

FINAL DATE RECEIVED: October 1990

ABSTRACT:

Volume I: Erosion Model for Dynamic Rill Networks
Part A: Introduction and Overview
Part B: Erosion Model Development

Presented is the development of a dynamic erosion model based on fundamental concepts of hydrology, sedimentology and probability. The model predicts erosion rates for varying surface conditions and will ultimately be used to evaluate new and existing tillage systems without requiring extensive *apriori* field measurements. In addition, the dynamic erosion model can be used to assess the impact of rill density, surface roughness, channel network development, and numerous other erosion sub-processes on sediment yield.

The dynamic erosion model contains a deterministic runoff and erosion component applied to a stochastically generated random surface. The random surface is generated using a defined random roughness and correlation length for a specified covariance function. The resulting flow networks are defined with a digital elevation model applied to the generated surface. The erosion component models interrill erosion delivered to the flow network, and rill erosion based on shear excess principles. In addition, rill geometry for a rectangular cross-section is based on flow conditions, soil properties, and surface geometry.

Volume II: Hydrologic Model for Dynamic Rill Networks

A comprehensive model has been developed for use in modeling the hydrologic response of rill network systems. The model, which is called HYMODRIN, is composed of both a hydrologic runoff component and a hydraulic channel routing component. The hydrologic component of the model uses a Green Ampt infiltration approach linked with a nonlinear reservoir runoff model. The channel routing component of the model is based on a finite element solution of the diffusion wave equations. In order to account for backwater effects, the model employs a dual level iteration scheme.

The model may be used in either a stand alone mode or as a part of a comprehensive integrated rill erosion model. In the latter case, the hydrologic data for the rill network and the associated interrill flow areas is provided by a geographic-hydrologic interface model called GHIM. This model accepts data from a digital elevation model and translates it into a form compatable with the hydrologic model.

This report contains the theoretical development and operating instructions for both GHIM and HYMODRIN. Computer listings for both programs are provided.

Volume III: Simulation of Random Rill Network Geometries on Agricultural Soils

Experiments were carried out with a rainfall simulator on a sloping agricultural plot 15 feet by 72 feet in dimension, with a slope of six percent. The experimentally observed rill geometries were recorded and the digital information was stored in disks for computer usage. A number of statistical parameters were estimated using the digitized samples of these observed rill networks. The statistics include spatially varying occurrence rates of the first order branching points, conditional occurrence rates of the second and higher order branching points, lengths of the branches, angular orientation of the branches and the configuration of each segment of the rill network. Using the occurrence rate and the locations of the observed branching points, a set of branching points was generated. The actual number of branching points and their locations were determined from a doubly stochastic Poisson random field. The path of the rills between the generated junction points and the fingertip branches are simulated by fitting a sinusoidal trajectory to the observed branch geometries. The coefficients defining the sinusoidal trajectory between generated junction points were sampled from a fitted multivariate normal distribution to account for the correlation between the estimated coefficients. The digitized paths of the observed rill network branches between two

consecutive branching points make up the sample set of the nonlinear curves to be fitted by nonlinear regression. The same approach was used for the rill segments between the last branching point and the tip of that branch. The straight line for this fingertip branch is a randomly assigned length based on the observed frequency histogram for that order of branches.

ORDER FROM:	National Technical Information Service Order Department Springfield, Virginia 22161 U.S.A.
ORDER NUMBER:	PB91-125369

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1282

PROJECT TITLE: Bacterial Transformations of Nitrate and Aldicarb in Anoxic Ground Waters of Long Island

PERFORMING ORGANIZATION: County of Suffolk, New York

PRINCIPAL INVESTIGATOR: D. G. Capone

START: September 1986

FINAL REPORT RECEIVED: May 1991

ABSTRACT:

We performed studies on the microbial transformation of nitrate and aldicarb and ground-water age-dating methods in the Upper Glacial aquifer of Long Island, New York. Microbial experiments were performed on sediments cored from l.5 and 15 m. Study transects were established at two sites, Connetquot State Park and Jamesport. Aging studies were performed on pumped well water. Microbial degradation pathways and degradation rates were examined under both aerobic and anaerobic conditions. Bacterial numbers and activity (using ^{14}C-glucose and ^{3}H-thymidine) were also quantified. Most if not all of nitrate reduction and aldicarb degradation was biologically mediated. Denitrification rates in aquifer sediments on a per gram basis were low (when compared to many soils and aquatic sediments), but depth integrated rates were as high as rates for sediments from other ecosystems. Aldicarb was also degraded at low rates, but more readily under anaerobic vs. aerobic conditions. Aldicarb degradation rates were highest for areas previously exposed to this contaminant, suggesting adaptation of the bacterial populations to degrade aldicarb. Age dating of ground water using radium isotopes, ^{226}Ra and ^{228}Ra, proved unsuccessful. A method developed using anthropogenic chlorofluoro-methanes as chronometers for ground-water flow proved successful as determined by a validated transport model.

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ORDER NUMBER: PB91-195826

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1287

PROJECT TITLE: Optimization of Remedial Programs for Contaminated Ground-water Supply Systems: Deterministic and Stochastic Analyses

PERFORMING ORGANIZATION: Cornell University

PRINCIPAL INVESTIGATORS: C. A. Shoemaker and P. L-F. Liu

START: September 1986

FINAL REPORT RECEIVED: May 1991

ABSTRACT:

A numerically efficient procedure is developed for computing optimal time-varying pumping rates for remediation of contaminated ground-water aquifers described by two-dimensional numerical models. The management model combines a pollutant transport model with a constrained optimal control algorithm. The transport model simulates the unsteady fluid flow and transient contaminant dispersion/advection in a two-dimensional confined aquifer. A Gelaerkin's finite element method and full implicit finite difference scheme is applied to solve the ground-water flow and contaminant transport equations. The constrained optimal control algorithm employs a hyperbolic penalty function. Several sample problems covering five to fifteen years of remediation are given to illustrate the capability of the management model to solve a ground-water quality control problem with a time-varying pumping policy and water-quality constraints. Previous applications of nonlinear optimization methods to two-dimensional ground-water remediation have only considered constant pumping rates in time. In this study, the optimal constant pumping rates are 75% more expensive than the optimal time-varying pumping rates, a result that supports the need to develop numerically efficient optimal control-finite element algorithms for ground-water remediation.

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U.S.A.

ORDER NUMBER: PB91-223636

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1289

PROJECT TITLE: Colloidal Fouling Elimination in Turbulent Flow Reverse Osmosis Treatment of Impaired Waters

PERFORMING ORGANIZATION: Massachusetts Institute of Technology

PRINCIPAL INVESTIGATOR: R. F. Probstein

START: September 1986

FINAL REPORT RECEIVED: March 1991

ABSTRACT:

An experimental study was carried out on colloidal fouling by iron hydroxide of reverse osmosis membranes using tubular asymmetric cellulose acetate membranes. The study sought to determine whether there exists in turbulent flow a threshold transmembrane (permeation) velocity below which no colloidal fouling takes place. The experiment established and a simple model confirmed that under stable colloid conditions where the colloid does not floc or aggregate, there does exist a threshold velocity in turbulent flow whose value is about the same as in laminar flow. Under unstable conditions, where electrolytes are present, a threshold velocity still exists but its value is greatly reduced. The threshold velocity phenomenon can be used in practice to reduce or eliminate colloid fouling for stable solutions, although it is not useful where electrolytes are present, as in seawater. Importantly, it is found that there is no advantage to employing turbulent flow to reduce fouling when operating at threshold conditions, as the threshold velocity value was found to be independent of the axial flow Reynolds number up to a value of 26,300.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-162859

PUBLICATIONS:

Cohen, R. D. and Probstein, R. F., 1986, Colloidal fouling of reverse osmosis membranes: Journal Colloid and Interface Science 114, p. 194-207.

Apostolides, A. A., 1987, Colloidal fouling elimination of reverse osmosis membranes: Sc.M. Thesis, Department of Mechanical Engineering, M.I.T., Cambridge, MA., June.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1294

PROJECT TITLE: Climate and Streamflow Variability Related to Surface Water Supply in the Western United States

PERFORMING ORGANIZATION: Colorado State University

PRINCIPAL INVESTIGATORS: T. B. McKee and N. J. Doesken

START: September 1986

FINAL DATE RECEIVED: January 1991

ABSTRACT:

Interrelated hydroclimatic elements were investigated to determine characteristics of the spatial and temporal climate variability in a five-state region in the northern Rocky Mountains, covering the 1951-1985 period. The three primary hydroclimatic elements analyzed were total water-year streamflow (ST), winter (October 1-March 31) accumulated precipitation (PR), and April 1 snowpack (SN).

Analysis of SN and PR data sets, from about 270 sites across the five-state study area, revealed that the 0.55 measure of variability isoline separated stable regions from unstable regions. The average magnitude of variability in the two types of regions differed by a factor of nearly two. The stable and unstable regions revealed a relationship of their variability with the aspect of mountain barriers, with W to NW barriers having stable regions and SW to S barriers having unstable regions.

Three basic and persistent patterns of annual SN values surfaced: years with a consistent anomaly over the entire region (wet or dry); years with a distinct north-to-south gradient; and average years. The wet-north/dry-south gradient patterns occurred only before 1974 and dry-north/wet-south gradient patterns did not occur before 1973. The long-term wet and dry periods experienced in the northern and southern regions of the five-state region are due to north-to-south gradient patterns.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-143115

PUBLICATIONS:

Changnon, D., McKee, T. B., and Doesken, N. J., 1985, Hydroclimatic variability in selected watersheds located in the Rocky Mountains: Preprints, AMS 6th Conference on Applied Climatology, 7-10 March, Charleston, South Carolina, p. 55-59.

McKee, T. B., Changnon, D., and Doesken, N. J., 1989, Data for hydroclimatic research in the Rocky Mountain Region: Preprints, AMS 6th Conference on Applied Climatology, 7-10 March, Charleston, South Carolina, p. 162-163.

Doesken, N. J., Changnon, D., and McKee, T. B., 1989, Interannual variations in snowpack in the Rocky Mountain Region: Proceedings, 57th Annual Western Snow Conference, Fort Collins, Colorado, 18-20 April, p. 21-30.

Changnon, D., McKee, T. B., and Doesken, N. J., 1990, Multidecadal variation of winter snowpack along the Rocky Mountains: Preprints, AMS 8th Conference on Hydrometeorology, 22-26 October, Ananaskis Provincial Park, Alberta, Canada.

Changnon, D., 1990, Hydroclimatic variability in the Rocky Mountain Region: Ph.D. Dissertation, Atmospheric Science Department, Colorado State University, Fort Collins, Colorado, December, 225 p.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1295

PROJECT TITLE: Mitochondrial Bioassay for Toxic Substances in Water

PERFORMING ORGANIZATION: University of Wisconsin

PRINCIPAL INVESTIGATOR: J. M. Harkin

START: August 1986

FINAL REPORT RECEIVED: April 1991

ABSTRACT:

A new rapid in vitro bioassay system has been developed that is suitable for monitoring water quality and determining toxicity of effluents, leachates, or chemical substances. In the bioassays developed, phosphorylating submitochondrial particles (SMP), prepared by sonic disruption of the heavy fraction of intact bovine heart mitochondria, serve as in vitro monitors of aquatic toxicity.

Two variations of the original reverse electron transfer (RET) test have been developed during the program project. One new test version, designated Electron Transfer (ETR) or Conventional Electron Transfer (CET), permits more sensitive detection of lipophilic toxicants (for example, PCBs, phthalates, DDT, etc.) by measuring the rate of nicotinamide adenine dinucleotide (NADH) oxidation by forward electron flowing in the mitochondrial electron transfer chain. The ETR test complements the RET bioassay and enables new test results to correlate better when compared statistically with 96-hour LC-50 values for standard toxicants in fish. The second test version, designated Facilitated Electron Withdrawal (FEW) or Facilitated Electron Diversion (FED), allows rapid, sensitive detection of chemicals such as paraquat and adriamycin that manifest their acute toxicity, mutagenicity, or carcinogenicity by inducing a prooxidant state in vitro. SMP are used to catalyze NADH-dependent enzymatic reduction of these chemicals to free radicals. The highly reactive species generated in this system reduce molecular dioxygen to the superoxide anion radical which is detected spectrophotometrically using the adrenochrome reaction. The anticancer drug adriamycin, the herbicides paraquat and diquat,

the analytical dye sulfonazo III, and the experimental carcinogen 4 nitro-quinoline-N-oxide have been used to test the sensitivity of this new method. This assay can be used to screen fresh water samples for the presence of pollutants which can generate oxygen-centered free radicals.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-192419

PUBLICATIONS:

Blondin, G. A., Knobeloch, L. M., Read, H. W., and Harkin, J. M., 1989, An in vitro submitochondrial bioassay for predicting acute toxicity in fish: Aquatic Toxicology and Environmental Fate: Eleventh Volume, ASTM, STP 1007, G. W. Suter II and M. A. Lewis, Eds., American Society for Testing Materials, Philadelphia, p. 551-563.

Knobeloch, L. M., Blondin, G. A., Lyford, S. B., and Harkin, J. M., 1990, A rapid bioassay for chemicals that induce prooxidant states: Journal of Applied Toxicology, vol. 10(1), p. 1-5.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1299

PROJECT TITLE: Nonequilibrium Adsorption During Reactive Contaminant Transport through Heterogeneous Aquifers

PERFORMING ORGANIZATION: University of Illinois

PRINCIPAL INVESTIGATOR: A. J. Valocchi

START: September 1986

FINAL DATE RECEIVED: October 1990

ABSTRACT:

This project addressed the case where ground-water pollutant transport is affected by hydraulic conductivity field heterogeneity and by nonequilibrium adsorption reactions. The research methodology consisted of development and application of numerical transport models. Adsorption was assumed to be governed by a first-order reversible rate expression with spatially uniform reaction parameters; hydraulic conductivity was assumed to be a realization of a lognormally distributed random field having isotropic exponential spatial covariance. Novel finite-difference ground-water flow and random-walk solute transport models that are highly efficient on supercomputer architectures were developed. These models were utilized to conduct a suite of numerical experiments for varying degrees of heterogeneity and for different reaction rates. The results indicated that the overall longitudinal spatial variance of the aqueous-phase solute plume could be expressed as the sum of the variance due to conductivity heterogeneity plus that due to adsorption kinetics. The latter effect can be approximately quantified by earlier results for perfectly stratified aquifers. An approximate simplified formula is presented to quantify the impact of kinetics relative to that of heterogeneity. The results show that deviations from local equilibrium behavior diminish as the variance of the ln K field increases.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-136200

PUBLICATIONS:

Elnawawy, O. A., Valocchi, A. J., and Ougouag, A. M., 1988, The cell analytical-numerical method for solution of the two-dimensional advection-dispersion equation: in Computational Methods in Water Resources, Vol. 2, Numerical Methods for Transport and Hydrologic Processes, M.A. Celia, et al., ed., Elsevier, Amsterdam, p. 21-26.

Valocchi, A. J. and Quinodoz, H. A. M., 1989, Application of the random walk method to simulate the transport of kinetically adsorbing solute: in Groundwater Contamination, L. M. Abriola, ed., IAHS Publ. No. 185, p. 35-42.

Valocchi, A. J., 1989, Spatial moment analysis of the transport of kinetically adsorbing solutes through stratified aquifers: Water Resources Research, 25(2), p. 273-279.

Meyer, P. D., Valocchi, A. J., Ashby, S. F., and Saylor, P. E., 1989, A numerical investigation of the conjugate gradient method as applied to three-dimensional groundwater flow problems in randomly heterogeneous porous media: Water Resources Research, 25(6), p. 1440-1446.

Valocchi, A. J., 1990, Numerical simulation of the transport of adsorbing solutes in heterogeneous aquifers: in Computational Methods in Subsurface Hydrology, Gambolati et al., eds., Computational Mechanics Publications, Southampton, p. 373-382.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1313

TITLE: Efficiency of Carbon Utilization by Thiobacillus Ferrooxidans

PERFORMING ORGANIZATION: University of Alaska

PRINCIPAL INVESTIGATOR: E. J. Brown

START: September 1986

FINAL REPORT RECEIVED: March 1991

ABSTRACT:

Thiobacillus ferrooxidans is an acidophilic microorganism that is normally associated with acid mine drainage. It is an obligate autotroph that grows readily at a pH of 2, with ferrous iron as the sole energy source. Yet, this organism appears to be quite ubiquitous, and has been isolated from a variety of aqueous and terrestrial environments that show no indication of acidity on a macro scale. In this study, we have investigated the steady-state growth, microbial ecology and biohydrometallurgical potential of T. ferrooxidans. The report is divided into two sections which summarize more detailed works which have been published in one thesis, one report, and one journal article. A third section summarizes our most recent results, which show that T. ferrooxidans can grow autotrophically with molecular hydrogen as a sole energy source.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-168989

PUBLICATIONS:

Hong, S., 1988, Arsenic removal by use of bioleaching after flotation concentration of an Alaskan silver ore: unpublished M.S. Thesis, University of Alaska, p. 75.

Hong, S., Luong, H. V., Maneval, D. R., and Brown, E. J., 1988, Biological benefication of an Alaskan sulfide ore: The Northern Engineer 20, p. 11-14.

Dixon, D. P. and Brown, E. J., 1987, The effects of suface disturbances on the leaching of heavy metals: Water Research Center, Institute of Northern Engineering, University of Alaska Fairbanks, Report IWR-110, p. 102

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1317

PROJECT TITLE: Development of Improved Water Application and Management Techniques for Moving Irrigation Systems

PERFORMING ORGANIZATION: University of Nebraska-Lincoln

PRINCIPAL INVESTIGATOR: D. L. Martin

START: September 1986

FINAL REPORT RECEIVED: September 1990

ABSTRACT:

We evaluated the effect of high frequency irrigation and sprinkler application packages on water and nitrogen use for corn irrigated with center pivot irrigation systems. High frequency (daily) irrigation did not increase corn yields in Nebraska. High frequency irrigation can reduce runoff if the soil is allowed to dry before initiating irrigation. The sprinkler package affects the water use efficiency of center pivots. Results show that evaporation of water droplets while in the air is very small (1-2 percent of the application). Evaporation from the wetted canopy and soil surfaces can be substantial and increases with the frequency of irrigation. High frequency irrigation with center pivots seems to be best suited to sprinkler packages that apply water below the crop canopy and that only wet part of the soil surface. However, the water application rate for these packages can be very high and may induce runoff if inter-row tillage is not used.

Irrigation and fertilizer management are needed to abate the buildup of nitrate in ground water. Frequent irrigation reduces nitrate leaching if watering is delayed until the soil dries to a point that minimizes deep percolation while avoiding crop water stress. However, slight water stress reduced both crop yield and nitrogen uptake. Plots on a silty clay loam soil that were not fertilized for four years yielded nearly the same as plots fertilized at the recommended rate, indicating that improved nitrogen management depends on better predicting the mineralization of organic nitrogen. Leaching of chemicals applied

with the irrigation water increases if preferential flow paths are available in the soil. If preferential flow does not occur chemicals already in the soil leach before chemicals in the irrigation water. Transfer function models were developed to predict preferential flow, but the input function for these models is unique to the way the chemical is applied and for the rate of water application, limiting the utility of the transfer function model.

OBTAINABLE FROM:	National Technical Information Service Order Department Springfield, Virginia 22161 U.S.A.
ORDER NUMBER:	PB91-223669

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1476

PROJECT TITLE: The Comparative Performance of Institutional Arrangements for Ground-water Resources

PERFORMING ORGANIZATION: Indiana University

PRINCIPAL INVESTIGATOR: E. Ostrom

START: September 1987

FINAL DATE RECEIVED: January 1991

ABSTRACT:

This study examined these questions: (1) Does the allocation of ground-water production rights in Southern California enhance the effectiveness of the management system in reducing exposure to risk and in increasing the efficiency of resource use? (2) Do less centralized ground-water management systems perform as well as, better than, or less well than more centralized management systems on criteria of compliance, effectiveness in reducing exposure, efficiency, equity, and adaptability? (3) Is there an optimal institutional "formula" for ground-water management?

A comparative case-study of the institutional development of eight ground-water basins located on the South Coastal Plain of California was performed, including: four basins in the San Gabriel River watershed (Raymond, West Coast, Central, and Main San Gabriel Basins); one within the Los Angeles River watershed (San Fernando Valley Basin); two in the Santa Ana River watershed (Orange County and Chino Basins); and the Mojave River Basin encompassing the Mojave River watershed.

The cases demonstrate that complex, water resource systems can be designed and managed by users at relatively low costs and high levels of effectiveness, equity, and adaptability without creating a sole "manager." These institutions are, however, delicate and require considerable craftsmanship. No single institutional formula can be prescribed that will match the diverse geologic, hydrologic, and historical patterns in an area.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-159459

PUBLICATIONS:

Blomquist, W., 1988, Raymond basin: the performance of institutions for ground-water management, volume 1. Bloomington: Indiana University, Workshop in Political Theory and Policy Analysis.

Blomquist, W., 1988, West basin: the performance of institutions for ground-water management, volume 2. Bloomington: Indiana University, Workshop in Political Theory and Policy Analysis.

Blomquist, W., 1988, Central basin: the performance of institutions for ground-water management, volume 3. Bloomington: Indiana University, Workshop in Political Theory and Policy Analysis.

Blomquist, W., 1990, San Gabriel Valley: the performance of institutions for ground-water management, volume 4. Bloomington: Indiana University, Workshop in Political Theory and Policy Analysis.

Blomquist, W., 1988, Orange County: the performance of institutions for ground-water management, volume 5. Bloomington: Indiana University, Workshop in Political Theory and Policy Analysis.

Blomquist, W., 1988, San Fernando Valley: the performance of institutions for ground-water management, volume 6. Bloomington: Indiana University, Workshop in Political Theory and Policy Analysis.

Blomquist, W., 1990, Chino Basin: the performance of institutions for ground-water management, volume 7. Bloomington: Indiana University, Workshop in Political Theory and Policy Analysis.

Blomquist, W., 1989, Mojave river basin: the performance of institutions for ground-water management, volume 8. Bloomington: Indiana University, Workshop in Political Theory and Policy Analysis.

Blomquist, W., 1990, Ground-water management through interjurisdictional coordination: Paper presented at the 7th Annual Donald G. Hagman Commemorative Conference, University of California, Los Angeles, March 7, 1990.

Ostrom, E., 1990, Analyzing long-enduring, self-organized, and self-governed CPRs: In Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge, MA: Cambridge University Press.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1477

PROJECT TITLE: Characterization of Fracture Geometry Utilizing Particulate Tracers and Borehole Temperature

PERFORMING ORGANIZATION: University of Notre Dame

PRINCIPAL INVESTIGATORS: S. E. Silliman and C. C. Cady

START: September 1987

FINAL REPORT RECEIVED: May 1991

ABSTRACT:

Prediction of flow and transport in fractured media requires characterization of the major mechanisms influencing movement of water and solutes within individual fractures. Among the tests utilized to parametrize these mechanisms are hydraulic and chemical tracer tests. Results from these tests have shown that the apertures estimated from hydraulic and tracer tests do not agree. In this project, the discrepancy between these estimates was investigated through numerical analysis and field tests involving combined hydraulic and chemical tracer tests. The theoretical results led to an explanation for the observed difference between these estimates based on the degree of anisotropy in the distribution of the aperture within the plane of a fracture. Field results were obtained which were consistent with the results predicted by the theory. In addition, this work has led to improvement of several field techniques for location of fracture interconnections. Included are a thermal monitoring technique and an improved heat-pulse flowmeter. Finally, initial field results demonstrated that particulate tracers can be transported between boreholes. It was observed, however, that at the flow rates utilized (approximately 0.06 liters/second), the background concentration of particulates makes analysis of field samples difficult.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-195776

PUBLICATIONS:

Silliman, S., Higgins, D., 1990, An analytical solution for steady-state flow between aquifers through an open well: Ground Water, 28(2), p. 184-190.

Silliman, S. E., 1989, An interpretation of the difference between aperture estimates derived from hydraulic and tracer tests in a single fracture: Water Resources Research, 25(10), p. 2275-2283.

Silliman, S. and Robinson, R., 1989, Identifying fracture interconnections between boreholes using natural temperature profiling: I. Conceptual basis: Ground Water 27(3), p. 393-402.

Silliman, S. E. and Deuell, R., 1989, Observations regarding comparison of hydraulic and chemical tracer test results: Fourth Canadian/American conference on Hydrogeology, Fluid Flow, Heat Transfer, and Mass Transport in Fractured Rocks, National Water Well Association, June 21-24, Banff, Alberta, Canada.

Silliman, S., Nicholas, J., and Shapiro, A., 1987, Estimating fracture connectivity using measurements of borehole temperatures during pumping: Focus Conference on Midwestern Ground Water Issues, National Water Well Association, April 21-13, Indianapolis.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1478

PROJECT TITLE: Sampling Strategies for Hydrological Properties and Chemical Constituents in the Upper Vadose Zone

PERFORMING ORGANIZATION: University of Arizona

PRINCIPAL INVESTIGATORS: A. W. Warrick, S. A. Musil, J. F. Artiola, D. M. Hendricks, and D. E. Myers

START: September 1987

FINAL REPORT RECEIVED: May 1991

ABSTRACT:

The primary field location was at the Maricopa Agricultural Center near Maricopa, Arizona. Properties which were evaluated at the surface were pH, EC, Cl, NO_3, SO_4, Ca, Mg, NA, gravel, sand, silt, clay, and water retained at 1/3, 1, and 15 bars. Those same properties were obtained for deeper depths (to 250 cm) at 30 of the points and saturated conductivity was found at 50 surface points. A second field was chosen near Marana, Arizona and all of the above determinations repeated except for the saturated hydraulic conductivity. In situ infiltration tests were run on 150 points at the Maricopa Agricultural Center. Included were tension infiltrometer determinations which result in sorptivity and unsaturated hydraulic conductivity values.

At the same time that the field sampling and data analysis were performed, theoretical investigations were pursued for these and other data. In particular, alternative interpolators were compared, use of auxiliary and secondary data explored and effects of sample "support effects" examined. Alternative interpolators included kriging, inverse distance weighting and nonparametic interpolators. Generally, for interpolations in space, kriging performs as well but is not greatly superior to the other techniques, such as inverse distance weighting. Advantages to be gained are variance estimates and an ability to predict for other sizes of support such as for block vs. point values. The nonparametric interpolators are specialized, but the general idea was to pursue an alternative to kriging which would include a variance component, but

this has not been completed as yet. The sample support effects were studied in order to connect the classical empirical relationships of Smith to geo-statistical analysis--as relates to variance predictions as a function of areas (or volumes) over which measurements are made.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-234724

PUBLICATIONS:

Zhang, R., Warrick, A. W., and Myers, D. E., 1990, Variance as a function of sample support size: Mathematical Geolology, v. 22, p. 107-121.

Lien, B. K., 1989, Field measurement of soil sorptivity and hydraulic conductivity: unpublished M.S. Thesis, University of Arizona, 93p.

Zhang, R., 1990, Soil variability and geostatistical applications: unpublished Ph.D. Dissertation, University of Arizona, 281 p.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1479

PROJECT TITLE: Application of Economic Analysis to Water Allocations and Fish Habitat Enhancements, John Day Basin

PERFORMING ORGANIZATION: Oregon State University

PRINCIPAL INVESTIGATOR: R. M. Adams

START: September 1987

FINAL DATE RECEIVED: November 1990

ABSTRACT:

This study uses an interdisciplinary approach to assess the economic efficiency of water allocations and fish habitat enhancements for chinook salmon and steelhead trout in the John Day River Basin, Oregon. Specific enhancements included water transfers to instream flow, habitat vegetation improvements, and habitat structural measures. The benefits of improved fish productivity included recreation and commercial uses. Streamflow and water temperature were found to be critical limiting factors in a majority of habitats. Low discharges posed limitations at sites where temperatures were elevated and at habitats where channel structure was simple. Attempts to improve habitat solely by increasing structural complexity were seldom successful. The economic efficiency of streamflow augmentation and habitat investments varied across sites, suggesting that policies to enhance fish production need to be tailored to local conditions.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-143123

PUBLICATIONS:

Cerda, A. A. and Adams, R. M., 1990, Estimating demand and benefits from salmon and steelhead sport fishing in the Central and Northeast regions of Oregon: Fifth International Conference; The International Institute of Fisheries Economics & Trade, December 3-6, 1990, Santiago, Chile.

Klingeman, P. and MacArthur, R. C., 1990, Sediment transport and aquatic habitat in gravel-bed rivers: in Hydraulic Engineering, Proceedings of the 1990 National Conference, Hydraulics Division, American Society of Civil Engineers, July, p. 1116-1121, San Diego, California.

Frizenschaf, J., 1988, Hydraulic influence on pool morphology - a laboratory investigation: M.S. Thesis; Civil Engineering Department, April 1988, Oregon State University, Corvallis, Oregon.

Huang, C. C., 1990, Local scour at isolated obstacles on river beds: Ph.D. Thesis; Civil Engineering Department, August 1990, Oregon State University, Corvallis, Oregon.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1481

PROJECT TITLE: Improving Management of Intrastate and Interstate Water Transfer in the Eastern United States

PERFORMING ORGANIZATION: Virginia Polytechnic Institute and State University

PRINCIPAL INVESTIGATOR: W. E. Cox

START: September 1987

FINAL DATE RECEIVED: November 1990

ABSTRACT:

Transfer of water from areas of abundance to areas of scarcity has long been a basic water-management tool, even in the eastern United States, but the increasing controversy over transfer is not resolved effectively by existing water-management institutions. In addition, these institutions impede conflict-resolving negotiations among the affected parties by providing such obstacles as property-rights uncertainty. This report documents the nature of the conflict-resolution process by means of case studies of successful and unsuccessful transfer proposals, including the areas of New York City, southeastern Virginia, and Boston. The characteristics of successful negotiation are described, and a decision-making process is proposed to facilitate negotiation while providing a back-up arbitration process to encourage good-faith negotiation and prevent unnecessarily protracted conflict. The process promotes water-transfer decision making that is sensitive to environmental concerns, efficiency in water use, and the equitable distribution of water-transfer gains. Concerns over environmental and distributional impacts are addressed by provisions for compensation broader than traditional arrangements. Alternative designs for administration of the proposed decision process are evaluated. Administrative options are presented for intrastate transfer and then extended to the interstate situation by considering available institutional mechanisms for resolving interstate water-use conflicts.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-136283

PUBLICATIONS:

Cox, W. E. and Shabman, L.A., 1990, Innovative compensation arrangements for resolving water transfer conflicts: Managing Water-Related Conflict: The Engineer's Role -- Proceedings of the Engineering Foundation Conference, American Society of Civil Engineers, New York, p. 94-109.

Cox, W. E., 1989, Interstate water management: Implication of recent Virginia/North Carolina conflicts: Legal, Institutional, Financial, and Environmental Aspects of Water Issues: American Society of Civil Engineers, New York, p. 203-206.

Cox, W. E., 1988, Tidewater Virginia's water supply problem: Implications for state water management: Critical Water Issues and Computer Applications: Proceedings of the 15th Annual Water Resources Conference, American Society of Civil Engineers, New York, p. 17-20.

Cox, W. E., 1989, State water allocation law: Its traditional and emerging roles: Contributed Papers and Abstracts for the Conference on Water: Laws and Management, American Water Resources Association, Bethesda, MD, p. 5B-3 through 5B-9.

Cox, W. E., 1989, The role of compensation in resolving water transfer conflicts: Water Resources Planning and Management: Proceedings of the 16th Annual Conference, American Society of Civil Engineering, New York, p. 87-90.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1482

PROEJCT TITLE: Bacterial Bioluminescence and Gene Probes in Optimizing the Maintenance and Expression of Biodegradative Plasmids in Ground Water

PERFORMING ORGANIZATION: University of Tennessee

PRINCIPAL INVESTIGATORS: G. S. Sayler and A. Layton

START: September 1987

FINAL REPORT RECEIVED: August 1991

ABSTRACT:

Reporter gene fusion technology and DNA hybridization gene probing techniques were developed and applied for quantifying the maintenance and activity of biodegradative bacteria of use in ground-water bioremediation and restoration. Transcriptional gene fusion using the bioluminescent genes (lux) of Vibrio fischeri were made with naphthalene catabolic genes (nah) of the NAH7 naphthalene catabolic plasmid harbored in Pseudomonas spp. The nah-lux gene fusions resulted in the development of bioluminescent reporter strains of Pseudomonas that were inducible for light production in the presence of naphthalene or the metabolic intermediate, salicylate. Light production was shown to be a direct response to naphthalene exposure, bioavailability, and biodegradation of naphthalene in contaminated water, subsurface soils, and in soil slurry treatment reactor systems. Using a combination of light response, antibiotic resistance patterns and a gene probe specific for naphthalene catabolism, both the unmodified naphthalene degrading Pseudomonas strains and the nah-lux reporter strains could be competitively maintained in continuous culture groundwater simulations in excess of 50 days.

Investigations were undertaken to characterize at the molecular level a catabolic plasmid associated with the degradation of the lesser chlorinated PCBs by Alcaligenes eutrophus. A series of three related PCB plasmids (pSS50, 60, and 70) were characterized and examined as potential candidates for PCB-lux gene fusions to develop reporter bacteria for PCB biodegradation using the

same molecular approach as the nah-lux model system. The host Alcaligenes was found to be an acceptable candidate for bioluminescent reporter development; however, further molecular identification of catabolic gene regions is necessary for creating PCB-lux reporter bacterial strains. The results of these investigations give clear evidence for the potential (1) to utilize molecular monitoring strategies for detecting specific ground-water contaminants, (2) for on-line measurements of the biodegradative activity of the microbes involved, and (3) for the development of new protocols for process monitoring and control.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB92-123330

PUBLICATIONS:

Hooper, S. W., Dockendorff, T. C., and Sayler, G. S., 1989, Characteristics and restriction analysis of the 4-chlorobiphenyl catabolic plasmid, pSS50: Applied Environmental Microbiology, v.55, p. 1286-1288.

Burlage, R. S., Hooper, S. W., and Sayler, G. S., 1989, The TOL (pWWO) catabolic plasmid: A review. Applied Environmental Microbiology, v.55, p. 1323-1328.

Sayler, G. S., Hooper, S. W., Layton, A., and King, J. M. H., 1990, Catabolic plasmids for environmental applications: A review. Microbial Ecology. v. 19, p. 1-20.

Sayler, G. S., King, J. M. H., Burlage, R. S., and Larimer, F., 1989, Molecular analysis of biodegradative bacterial populations: Application of Bioluminescence Technology. Division of Environmental Chemistry, American Chemical Society, Boston, Massachusetts.

Sayler, G. S. and Layton, A. C., 1990, Environmental application of nucleic acid hybridization: Annual Review Microbiology, v. 44, p. 635-648.

Hooper, S. W., Pettigrew, C. A., and Sayler, G. S., 1990, Ecological fate, effects, and prospects for the elimination of environmental polychlorinated biphenyls (PCBs): Environmental Toxicology Chemistry, v. 9, p. 655-667.

King, J. M. H., DiGrazia, P. M., Applegate, B., Burlage, R., Sanseverino, J., Dunbar, P., Larimer, F., and Sayler, G. S., 1990, Novel bioluminescent reporter technology for naphthalene exposure and biodegradation: Science, v. 249, p. 778-781.

Burlage, R. S., Bemis, L. A., Layton, A. C., Sayler, G. S., and Larimer, F., 1990, Comparative genetic organization of incompatibility group P degradative plasmids: Journal of Bacteriology, v. 172.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1484

PROJECT TITLE: Investigation of Multicomponent Sorption and Desorption Rates in Saturated Ground-Water Systems

PERFORMING ORGANIZATION: University of North Carolina

PRINCIPAL INVESTIGATORS: C. T. Miller and J. A. Pedit

START: August 1987

FINAL REPORT RECEIVED: May 1991

ABSTRACT:

Laboratory experiments were performed and mathematical models were developed and used to analyze sorption and desorption processes of hydrophobic organic solutes to subsurface materials. The work included consideration of both single and multisolute systems, while experiments were performed in both batch and one-dimensional column reactor systems. Mathematical model development included a variety of batch, one-dimensional, and two-dimensional models for simulating single and multi-component sorption processes described by nonlinear equilibrium expressions and diffusional rate models. Petrov-Galerkin finite element methods were used to accommodate sharp-front problems, while sorption rates were simulated using a method of lines solution procedure. Numerical procedures used also included operator splitting methods and consideration of parallel processing. A complete and consistent set of multicomponent sorption rate and equilibrium experiments were performed for both solid materials using the solute lindane and 1,2,4-trichlorobenzene. These experiments reinforced the findings that time scales for equilibration are on the order of months, and sorption equilibrium relationships are nonlinear. Competition was not observed in batch experiments, either with regard to sorption equilibrium or with regard to the rate of sorption. This lack of competition did not agree well with predictions made using ideal adsorbed solution theory. However, significant competition was observed in a set of column experiments. It is concluded that column experiments provide a more sensitive indicator of competitive sorption than batch experiments.

OBTAINABLE FROM:	National Technical Information Service Order Department Springfield, Virginia 22161 U.S.A.
ORDER NUMBER:	PB91-223651

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1490

PROJECT TITLE: Remote Determination of Soil Moisture and Evapotranspiration from Thermal Infrared Measurements: Detection of a Drying Threshold

PERFORMING ORGANIZATION: Pennsylvania State University

PRINCIPAL INVESTIGATORS: T. N. Carlson and J. M. Russo

START: September 1987

FINAL REPORT RECEIVED: May 1991

ABSTRACT:

Results in this report appear in several reviewed publications (Carlson and others 1990, 1991). Important objectives in the work were to (1) model the water movement through the soil/plant/atmosphere system and (2) to use, in conjunction with this model, remote measurements of infrared surface temperature and a vegetation index to calculate soil water content and (3) determine whether water stress can be detected radiometrically over vegetation, specifically to identify the threshold at which this detection is possible. The underlying purpose was to understand how to use these measurements for remotely estimating soil water content over both bare soil and vegetation, and to specify the limits of accuracy in the soil water content estimates. Much of the modeling efforts have been devoted to improving the vegetation component of the model. Sensitivity tests with our vegetation model suggest that water stress in vegetation may be detectable for a period of a few days prior to wilting, provided that the atmospheric demand is large, appropriate threshold leaf water potential exists and plant storage capacity is not large. Horizontal variations in radiometric surface temperature over sparse vegetation may simply reflect horizontal variations in canopy density rather than horizontal variations in soil water content.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-195818

PUBLICATIONS:

Carlson, T. N., 1991, Recent advances in modeling the infrared temperature of vegetation canopies: Chapter 21 in Land Surface Evaporation: Measurements and Parameterization, J. P. Andre and T. J. Schmugge, eds., Springer Verlag, Chapter 21, p. 349-358.

Carlson, T. N., Perry, E. N., and Schmugge, T. J., 1990, Remote estimation of soil moisture availability and fractional vegetation cover for agricultural fields: Agricultural and Forest Meteorology, 52, p. 45-69.

Lynn, B. and Carlson, T. N., 1990, A model illustrating plant versus external control of transpiration: Agricultural and Forest Meteorology, 52, p. 4-43.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1493

PROJECT TITLE: Effect of Aquatic Exposure and Disinfection on the Virulence of Enteric Pathogenic Bacteria

PERFORMING ORGANIZATION: Montana State University

PRINCIPAL INVESTIGATOR: G. A. McFeters

START: August 1987

FINAL REPORT RECEIVED: May 1991

ABSTRACT:

Studies were conducted to examine the persistence of enteric pathogens and their virulence-related properties with exposure to aquatic stress and disinfection. The initial effort was devoted to the adaptation of image analysis instrumentation in the rapid assessment of bacteria viability and injury in water using the direct viable count (DVC) technique. This analytical approach proved to be very useful in generating sufficient objective data for rigorous statistical analysis in a short time. Using this approach, it was found that a range of enteric pathogenic and indicator bacteria each have different optima for both nalidixic acid and nutrients. This observation indicated that the common practice of using one level of these ingredients can lead to artifactual results. A series of experiments also examined the survival of enteric pathogens in water and their response to suboptimal disinfection. These results revealed that the pathogens have extended persistence in temperate, agricultural surface water, and that experiments using enclosed vessels, "microcosms", can lead to misleading results concerning both survival and extended pathogenic potential. Exposure to low concentrations of chlorine also led to injury and reduced virulence-related properties.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-195800

PUBLICATIONS:

Singh, A., Pyle, B. H., and McFeters, G. A., 1989, Rapid enumeration of viable bacteria by image analysis: Journal of Microbiology Methods 10, p. 91-101.

Singh, A., Yu, F-. P., and McFeters, G. A., 1990, Rapid detection of chlorine-induced bacterial injury by the direct viable count method using image analysis: Applied Environmental Microbiology 56, p. 389-394.

McFeters, G. A., Egli, T., Wilberg, E., Alder, A., Schneider, R., Snozzi, M., and Giger, W., 1990, Activity and adaptation of NTA-degrading bacteria: field and laboratory studies: Water Research 24, p. 875-881.

McFeters, G. A. and Singh, A., 1991, Effects of aquatic environmental stress on enteric bacterial pathogens: Journal of Applied Bacteriology Symp. Suppl. 115S-120S.

Singh, A. and McFeters, G. A., 1990, Injury of enteropathogenic bacteria in drinking water: in G. A. McFeters (ed.) Drinking Water Microbiology: Progress and Recent Developments, Springer-Verlag, New York, p. 368-379.

McFeters, G. A., 1990, Enumeration, occurrence and significance of injured indicator bacteria in drinking water: in G. A. McFeters (ed.) Drinking Water Microbiology: Progress and Recent Developments, Springer-Verlag, New York, p. 378-392.

McFeters, G. A., 1990, ed. Drinking Water Microbiology: Progress and Recent Developments, Springer-Verlag, New York, 502 p.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1496

PROJECT TITLE: Molecular Biological Probes for Assessing Effects of Environmental Xenobiotics at Sublethal Levels in Fish Reproduction

PERFORMING ORGANIZATION: University of Maryland

PRINCIPAL INVESTIGATORS: A. K. Berndtson and T. T. Chen

START: September 1987

FINAL REPORT RECEIVED: May 1991

ABSTRACT:

The wide-spread use of polychlorinated biphenyls (PCBs) and/or polynuclear aromatic hydrocarbons (PAH) in pesticides and industrial reagents has caused a significant accumulation of these compounds in the aquatic ecosystems. Fish contaminated with these chemicals demonstrate several pathological conditions. Unfortunately, detailed biochemical and molecular studies investigating the sublethal effects of these compounds on fish growth, development, and reproduction have not been conducted. Although, there are methods available to measure the concentrations of PCBs and PAHs in the environment, these methods do not determine the pathological effects caused by these organic pollutants. Therefore, there is a need to develop rapid, reliable, and sensitive bioassays to assess the toxic effects of PCBs and PAHs present in the aquatic ecosystem at sublethal levels.

Studies conducted in our laboratory showed that sublethal levels of PCB and Mirex caused a reduction in the production of an egg yolk protein, vitellogenin, in juvenile rainbow trout induced with 17 -estradiol. We hypothesized that the reduction of vitellogenin could serve as a biochemical parameter to assess the effects of organic pollutants on fish reproduction.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-242891

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1497

PROJECT TITLE: Tracer Gas Method for Shallow Bays

PERFORMING ORGANIZATION: University of Texas - Austin

PRINCIPAL INVESTIGATOR: E. R. Holley

START: September 1987

FINAL REPORT RECEIVED: August 1991

ABSTRACT:

The objective of this project was to use laboratory and field testing to investigate the potential of the modified tracer gas technique to determine gas transfer rates in shallow bays. A series of laboratory tests were conducted to determine what effect biodegradation or chemical decomposition may have on propane samples in field conditions. These tests showed propane to be very stable in a variety of water quality conditions. Also, mixing tank tests were conducted to determine the effect of salinity on the gas transfer rates of oxygen and propane.

Field tests using propane and Rhodamine WT tracers were conducted to adapt the tracer gas method for use in shallow bays. The tests addressed developing methods of sampling the tracer cloud to obtain reliable results. The procedures evolved to sampling the cloud at a variety of horizontal points and at different depths. The analysis then uses the samples with the highest concentrations because it is essential that samples for different times come from the same part of the cloud. The results indicate that the surface gas transfer coefficients for a given wind speed are somewhat smaller than would be predicted from previous open sea and laboratory experiments. "Dye decay bottles" containing the dye in bay water were suspended in the bay during the field tests to determine decay rates. The method definitely yields better results than laboratory testing for decay rates, but the method needs refinement.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-234757

COMPLETED PROJECT

GRANT NUMBER	14-08-0001-G1498
PROJECT TITLE:	The Molecular Structure Basis for the Mutagenicity of Lignin- and Humic-Derived Chlorofuranones
PERFORMING ORGANIZATION:	Research Foundation of the State University of New York
PRINCIPAL INVESTIGATOR:	R. T. LaLonde
START:	September 1987
FINAL REPORT RECEIVED:	February 1991

ABSTRACT:

The disinfection and industrial chlorination of humic - and lignin - containing water produces non-volatile genotoxins, the most potent among them being the direct acting mutagen MX (3-chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone, compound 1). Finding the essential features of MX structure that make this compound such a potent genotoxin was the goal of the project. Accordingly, the structure of MX was varied through the systematic replacement of the C1 atoms and the OH group by H. Thereafter, each compound was assayed in the Ames mutagenicity assay using Salmonella typhimurium (TA100). A total of ten 4-methyl-2(5H)-furanones and two 2(5H)-furanones were prepared and assayed. New methods were developed for preparing MX and members of the MX series that had not been prepared previously. Stability of the compounds under assay conditions was ascertained, and the pK'_a values for compounds possessing a C-5 OH group were determined. MX was the most mutagenic of the series. Its mutagenicity diminished by ten fold through replacement of C-5 OH or C-6 C1 by H. However, the same replacements by H in a second compound (3-chloro-4-(chloromethyl)-5-hydroxy-2(5H)-furanone, compound 2) resulted in the largest mutagenicity reductions of any in the entire series; these reductions amounted to 100 to 1000 fold. The C-3 C1 by H replacement amounted to a 100 fold reduction. These findings revealed that the minimum substitution required for potent mutagenicity is already incorporated in compound 2. The findings of

this research will aid mutagenicity predictions for newly isolated, chlorine-substituted 4-methyl-2(5H)-furanones, and, thereby, assist risk assessment of water repudiation procedures involving chlorination. Taking a broader view, the findings suggest that for a series of closely related compounds, genotoxic potency does not abruptly change to non-toxicity. Instead, genotoxity diminishes gradually.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-159442

PUBLICATIONS:

LaLonde, R. T., Perakyla, H., Cook, G. P., and Dence, C.W., 1990, The contribution of the 5-hydroxyl group to the mutagenicity of mucochloric acid: Environmental Toxicology and Chemistry, v. 9, p. 687-691.

LaLonde, R. T., Perakyla, H., and Hayes, M. P., 1990, Potentially mutagenic, chlorine substituted 2(5H)-furanones: studies of their synthesis and NMR properties: Journal Organic Chemistry, v. 55, p. 2847-2855.

LaLonde, R. T., Perakyla, H., Ishiguro, Y., Clardy, J., and Brinen, L. S., 1990, Structure of an anhydride related to a mutagenic component of drinking water, 3-chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone: Chemical Research in Toxicology, v. 3, p. 404-405.

LaLonde, R. T., Cook, G. P., Perakyla, H., Dence, C. W., and Babish, J. G., 1991, The mutagenicity and assay stability of 3-chloro-4-(dichloromethyl)-5-hydroxy-2(5H) furanone (MX) and its open- and closed-ring analogs: Environmental and Molecular Mutagenesis, v.17, p. 40-48.

LaLonde, R. T., Cook, G. P., Perakyla, H., and Dence, C.W., 1991, The effect on mutagenicity of the stepwise removal of hydroxyl group and chlorine atoms from 3-chloro-4-(dichloromethyl)-5-hydrology-2(5H)-furanone [MX]: ^{13}C NMR chemical shifts as determinants of mutagencity: Chemical Research in Toxicology, v. 4, p. 35-40.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1501

PROJECT TITLE: Surface-Chemical Factors Affecting Transport of Bio-Colloids in Subsurface Porous Media

PERFORMING ORGANIZATION: University of Arizona

PRINCIPAL INVESTIGATOR: R. C. Bales

START: September 1987

FINAL DATE RECEIVED: October 1990

ABSTRACT:

Adsorption and transport of bacteriophage and Poliovirus were studied in laboratory experiments and in a month-long field injection study. In the column experiments, adsorption of the bacteriphages PRD-1 and MS-2 to silica beads at pH 5.0-5.5 was reversible, however release of attached phage was slow and breakthrough curves exhibited significant trailing. Modeling the experimental curves using a one-dimensional advection-dispersion equation with pseudo-first-order attachment and release gave rate coefficients on the order of 10^{-4} s for adsorption and 10^{-6}-10^{-4} s for desorption. Corresponding time scales for bacteriophage removal were hours for adsorption and days for desorption. The sticking efficiency (alpha) for phage attachment was near 1.0. Phage release was enhanced by raising pH and introducing surface-active chemical species. In a series of batch experiments, MS-2 adsorbed strongly to a hydrophobic surface, octadecyltrichlorosilane-bonded silica, at both pH 5 and 7. Adsorption to the unbounded silica at pH 5 was linear, but was 40 (with Ca) to 400 (without Ca) times less than adsorption to the bonded surface. Neither MS-2 nor PRD-1 adsorbed to unbonded silica at pH 7. The slow adsorption, strong pH dependence and reversibility aspects of the laboratory experiments were apparent in the field results.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-107326

PUBLICATIONS:

Bales, R. C., Gerba, C. P., Grondin, G. H., and Jensen, S. L., 1989, Bacteriophage transport in sandy soil and fractured tuff: Applied and Environmental Microbiology, v. 55, no. 8, p. 2061-2067.

Bales, R. C., Hinkle, S.R., Kroeger, T. W., and Stockling, K., 1991, Bacteriophage adsorption during transport through porous media: Environmental Science and Technology, v. 25, no. 12, p. 2088-2095.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1502

PROJECT TITLE: Water and Wastewater Filtration: A Particle Perspective

PERFORMING ORGANIZATION: University of Texas

PRINCIPAL INVESTIGATORS: D. F. Lawler, J. L. Darby, T. P. Wilshusen, S. I. Koolik, and R. S. Cushing

START: September 1987

FINAL REPORT RECEIVED: May 13, 1991

ABSTRACT:

Depth filtration removes particles by attaching them to the media or to previously-retained particles. Because of the latter, filters improve their efficiency over time, a process known as ripening. The research objectives were to (1) determine experimentally changes in particle size distribution and development of head loss in a filter bed over time and depth under varying physical conditions, and (2) compare the experimental observations to predictions from mathematical methods of filtration performance. Laboratory experiments were performed with four different types of suspensions: (1) latex particles (mondodisperse, bi-modal, and tri-modal suspensions); (2) effluent from a secondary wastewater treatment plant; (3) water from a point in a drinking water plant after sedimentation but before filtration, and (4) lake water from a drinking water source. The latter three types emulated the common uses of filtration in wastewater and drinking water treatment.

Ripening was observed in virtually all experiments, and was particularly dramatic for particles in the range of approximately 1 μm. Favorable surface chemical conditions between particles and media and between particles in suspension and previously-retained particles are essential for ripening. Flock break-off was irrefutably evident in the latex experiments and is the only apparently reasonable explanation for some results of other experiments. The surface area of the captured particles is the principal determinant of the increase in head loss. Mathematical models are well-developed for clean bed conditions; theoretical models developed for ideal conditions predict well the

initial removal for real suspensions like those tested from the treatment plants and lakes. Significant improvement in the models is needed to account for the complex behavior of particles in filters, including the potential movement of particles around the surface of the media after being captured.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-195784

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1503

PROJECT TITLE: Evaluation and Design of Geophysical Monitoring Network for Ground-water Contamination

PERFORMING ORGANIZATION: University of Nebraska-Lincoln

PRINCIPAL INVESTIGATOR: I. Bogadi

START: September 1987

FINAL REPORT RECEIVED: March 1991

ABSTRACT:

Ground-water contamination has emerged as one of the Nation's primary environmental concerns. Reliable, rapid, and cost-effective detection and remedial action can contribute to minimizing the adverse environmental and economic impact of ground-water contamination. This report contributes to aquifer remediation by developing a set of planning tools for detection, mapping, monitoring, and remediation of contaminated aquifers. The report is divided into three main sections that correspond to a typical sequence of actions resulting in a final remedial action plan for handling contamination at a particular site.

The first section develops a methodology for detecting and mapping suspected contamination using multiple sources of data. Different data types are combined by using a modified form of kriging with uncertain data, termed compound kriging. In addition, the use of fuzzy set theory merged with geostatistics is explored as a possible mapping technique when variogram parameters are difficult to quantify.

A decision support system for observation network design is presented in the second section. Network design is approached from a multiple objective decisionmaking perspective. The objective is to identify the preferred network design while considering the trade-off between performance and cost. Geostatistical variance reduction analysis and prior knowledge related to the site are used as performance measures in the decision support system.

A remedial action design support system is described in the third section. Three dimensional geostatistical simulation and analytical ground-water modeling are used to assess the need for further remedial action planning. In addition, a methodology for measuring the performance of candidate remediation systems under conditions of uncertainty in aquifer parameters and plume location is presented. These performance measures, combined with cost factors, are used in a multiple-criteria decision making system to determine the preferred clean up system for a site being investigated.

Each of the methods developed in this report has been demonstrated using data collected from the site of a low-level radioactive industrial waste reprocessing facility near Wood River Junction, Rhode Island.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-162842

PUBLICATIONS:

Kelly, W.E., Bogardi, I., Woldt, W., and Bardossy, A., 1989, Combining surface geoelectrics and borehole measurements for contamination control: IAHS publication 188, Groundwater Management: Quantity and Quality, Benidorm, Spain, October.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1627

PROJECT TITLE: Mechanisms of Resistance to Organic Chemical Pollutants by Marine Phytoplankton

PERFORMING ORGANIZATION: State University of New York

PRINCIPAL INVESTIGATORS: C. F. Wurster and E. M. Cosper

START: September 1988

FINAL REPORT RECEIVED: June 1991

ABSTRACT:

Clones of Ditylum brightwellii and Thalassiosira nordenskioldii were isolated from New York coastal waters and PCB-resistance in D. brightwellii was induced in the laboratory by exposure to increasing concentrations of PCBs. Resistance could not be similarly induced in T. nordenskioldii but was serendipitously discovered in cultures which had undergone sexual reproduction.

Cell size of the resistant strains was substantially increased in both species. Larger vacuole space seemed to account for this in D. brightwellii, whereas in T. nordenskioldii larger cells contained more carbon. Tracer experiments with ^{14}C-PCB indicated PCB accumulation per unit carbon was less in resistant strains of both species. Neutral lipid content per cell, as determined using the fluorophore Nile Red, was similar for resistant and sensitive strains of both species. Sub-cellular examination of lipid droplets in D. brightwellii suggested the PCB-resistant strain may be sequestering this lipophilic toxicant in a location removed from physiological activity. In T. nordenskioldii a decreased ratio of neutral lipid:carbon may reduce intra-cellular accumulation of PCBs. These diatom species have developed resistance in the highly PCB-polluted Hudson River estuary and, since they are the preferred food of dominant copepods, may offer less PCBs per unit carbon ration to zooplankton grazers.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER:

PUBLICATIONS:

Cohen, M. K., West, A.S., Cosper, E. M., and Wurster, C. F., 1991, Mechanisms of resistance to polychlorinated biphenyls (PCB) in two species of marine diatoms: Journal of Marine Biological Association U. K., v. 71, p. 247-263.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1628

PROJECT TITLE: Turbulent Mixing at Freshwater Saltwater Interfaces

PERFORMING ORGANIZATION: California Institute of Technology

PRINCIPAL INVESTIGATOR: E. J. List

START: August 1988

FINAL REPORT RECEIVED: March 1991

ABSTRACT:

Turbulent mixing processes in density-stratified flows have been evaluated in hydraulic laboratory simulations. The mechanisms involved in these mixing processes have been studied using laser-based measurements of the fluid velocity and density distributions in fluids that have been rendered optically homogeneous by refractive index matching.

A general theory to describe both the flow fields and the mixing has been developed and experimentally verified in the condition where entrainment occurs primarily in a supercritical internal flow. An extensive experimental study of the more difficult case of entrainment into sub-critical flows has been completed and a theory is in development.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-162867

PUBLICATIONS:

Rasi, M., List, E. J., Sullivan, G., and Dugan, R., 1989, Mixing in Density-Stratified Conjugate Flows: Proceeding of Tenth Australasian Conference on Fluid Mechanics, University of Melbourne, December.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1631

PROJECT TITLE: Risk Management for Nitrate Contaminated Ground-water Supplies

PERFORMING ORGANIZATION: University of Nebraska -Lincoln

PRINCIPAL INVESTIGATORS: M. F. Dahab and I. Bogardi

START: September 1988

FINAL REPORT RECEIVED: April 1991

ABSTRACT:

To reduce nitrate risk from ground-water supplies, several strategies were developed based on an acceptable level of human health risk, the reasonableness of nitrate control cost, and the technical feasibility of nitrate control methods. While high cost strategies may provide a high degree of human health risk protection, low cost ones may not provide adequate protection. Therefore, the objectives of risk reduction and cost are in conflict with each other. The ultimate goal of nitrate risk management is to determine, under a great deal of uncertainty, which strategy "best" satisfies the human health risk reduction and nitrate control cost criteria. The methodology addresses specific, yet common, cases of ground-water contamination in the midwestern United States. A new systems analysis tool, a combined probabilistic and fuzzy set approach, is used to address uncertainties common to risk management. In addition to addressing different strategies for nitrate control, different nitrate inputs (point and non-point sources) also were considered in the development of this methodology.

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Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-192427

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1634

PROJECT TITLE: Model Identification and Parameter Estimation Stochastic Demand Models

PERFORMING ORGANIZATION: University of Arizona

PRINCIPAL INVESTIGATOR: S. Sorooshian

START: September 1988

FINAL REPORT RECEIVED: August 1991

ABSTRACT:

It is well known that when the input variables of the linear regression model are subject to noise contamination, the model parameters cannot be estimated uniquely. This, in the statistical literature, is referred to as the identifiability problem of the errors-in-variables models. Further, in linear regression, there is an explicit assumption of the existence of a single linear relationship. The statistical properties of the errors-in-variables models under the assumption that the noise variances are either known or that they can be estimated are well documented. In many situations, however, such information is neither available nor obtainable. Although under such circumstances one cannot obtain a unique vector of parameters, the space, Ω, of the feasible solutions can be computed. Additionally, assumption of the existence of a single linear relationship may be presumptuous as well. A multi-equation model similar to the simultaneous equation models of econometrics may be more appropriate.

The goals of this report are the following: (1) to present analytical techniques or algorithms to reduce the solution space, Ω, when any type of prior information exact or relative, is available; (2) to examine the data covariance matrix, Σ, to determine whether or not Ω is bounded. If Ω is not bounded, a multi-equation model is more appropriate. The methodology for identifying the subsets of variables within which linear relations can feasibly exist is presented; (3) ridge regression is commonly employed in order to reduce the problems caused by collinearity. This is achieved by perturbing the diagonal elements of Σ. In certain situations, applying ridge regression causes some of the coefficients to change signs. An analytical technique is presented to measure

the amount of perturbation required to render such variables ineffective. This information can assist the analyst in variable selection as well as deciding on the appropriate model; (4) for the situations when Ω is bounded, a new weighted regression technique based on the computed upper bounds on the noise variances is presented. This technique will result in identification of a unique estimate of the model parameters. Finally, two case studies in domestic water use in the city of Tucson, Arizona, are presented to further expose the capabilities of the proposed techniques in modeling as well as prediction.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-234708

PUBLICATIONS:

Vazirinejad, S., 1990, A new look at simultaneous-equations, weighted-regression, and noise-in-variables models: Journal of Applied Mathematics and Computation, v. 40, no. 3, p. 187-202.

Vazirinejad, S., 1989, Estimation of parameter bounds in stochastic linear systems: Unpublished Ph.D. dissertation, Department of Systems and Industrial Engineering, The University of Arizona, Tucson.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1635

PROJECT TITLE: The Role of Humic Substances in the Partitioning and Transport of Copper (II) in Ground-water Aquifers

PERFORMING ORGANIZATION: University of Arizona

PRINCIPAL INVESTIGATORS: M. Conklin and G. L. Amy

START: September 1988

FINAL REPORT RECEIVED: July 1991

ABSTRACT:

Partitioning and transport of Cu (II) in the presence of natural organic matter (NOM) were investigated in both batch and continuous-flow column experiments. Experimental variables included: pH (6.2 and 7.5), background electrolyte and different NOM sources and isolation procedures. Ground-water NOM was studied in its original ground-water matrix and as isolated humic substances. Porous media were either SiO_2 or a mixture of SiO_2 and Al_2O_3. Cu (II) affinity varied for different sources of organic matter; strongest binding was to isolated ground-water humates. This bonding may be due to the presence of competing cations (Mg^{2+} and Ca^{2+}) in experiments using NOM in the ground-water matrix. Results of column experiments at pH 6.2 suggest that mobile humates facilitate the transport of Cu (II) by lowering the free Cu (II) concentration. Mineral-bound humics retarded the transport of Cu (II) by increasing the concentration of immobile binding sites and by binding considerably more Cu (II) per mass carbon than aqueous humics. Column experiments at pH 7.5 show NOM greatly facilitated transport of Cu (II) compared to pH 6.2. The steady state partitioning of Cu (II) to the immobile phase was predicted from Langmuir isotherms while the transport of Cu (II) was predicted by applying these isotherms to the equilibrium one-dimensional transport model.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB92-118132

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1638

PROJECT TITLE: Innovative Approach to Determine Retardation Factors of Organic Contaminants in Ground-water Systems

PERFORMING ORGANIZATION: University of Minnesota

PRINCIPAL INVESTIGATOR: S. J. Eisenreich

START: September 1988

FINAL REPORT RECEIVED: May 1991

ABSTRACT:

To elucidate the mechanism and magnitude of sorption of hydrophobic organic chemicals (HOC_S) to mineral surfaces, sorption experiments were conducted using a homologous series of alkylbenzenes (benzene, toluene, ethylbenzene, propylbenzene, butylbenzene) and well-characterized x-Al_2O_3 corundum. A headspace analysis system was constructed, characterized, and the methodology developed for studying sorption to mineral solids. This method determines the activity of the analyte in the headspace in equilibrium with water (Henry's Law) or with mineral solids. Henry's Law constant for the alkylbenzenes was determined repeatedly as a function of temperature (5^o to 30^oC) and ionic strength (10^{-4} to $10^{-2}M$) at constant pH = 7.0. The method delivered precise measurements of Henry's Law ($\pm$2%) and sorption coefficients (~$\pm$2-10%). Sorption isotherms suggest that alkylbenzenes sorbed to the surface enhanced benzene sorption at high surface coverages with little evidence of surface association at low surface coverages. Increasing solids concentration unexpectedly resulted in the decrease of the sorption constant. A general mechanism for the sorption of HOCs to mineral solids is proposed.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-195792

PUBLICATIONS:

Perlinger, J. A., Eisenreich, S. J., Capel, P. D., Carr, P. W., and Park, J. H., 1990, Adsorption of a homologous series of alkylbenzenes to mineral oxides at low organic carbon content using headspace analysis: Water Science Technology, v. 22, n. 6, p. 7-14.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1642

PROJECT TITLE: Influence of Microbial Transport Processes on In Situ Biodegradation of Ground-water Contaminants

PERFORMING ORGANIZATION: Montana State University

PRINCIPAL INVESTIGATORS: A. B. Cunningham and W. G. Characklis

START: September 1, 1988

FINAL REPORT RECEIVED: February 5, 1991

ABSTRACT:

A fundamental understanding of both transport and transformation processes is essential to the development of technically sound remediation strategies for ground-water contamination. Accordingly, the goal of this project is to enhance the rate and efficiency of in situ microbial degradation of subsurface contaminants through an improved understanding of processes which govern transport, attachment, growth, and activity of microorganisms in porous media. This report is organized into the following sections: TRANSPORT PROCESSES: contains experimental methods and results which document the effect of biofilm accumulation on the transport of water, nutrients, and suspended cells in one-dimensional porous media flow reactions (objective 1); EFFECTS OF CELL STARVATION AND MOTILITY: presents experimental procedures and results describing transport characteristics of starved vs. growing and motile vs. nonmotile cells in porous media (objective 2); MODELING MICROBIAL TRANSPORT AND ACTIVITY: describes development of a mathematical model which simulates contaminant biodegradation/bio-sorption, nutrient depletion and biomass accumulation in one-dimensional porous media flow (objective 3); BIOREMEDIATION GUIDELINES: summarizes relevant information in the form of guidelines useful to decision makers concerned with bioremediation of contaminated water and soil (objective 4).

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-223644

PUBLICATIONS:

Cunningham, A. B., 1989, Hydrodynamics and solute transport at the fluid-biofilm interface: Dahlem Workshop Report No. 46, Structure and Function of Biofilms, John Wiley and Sons.

Cunningham, A. B., Bouwer, E. J., and Characklis, W. G., 1989, Biofilms in porous media: Chapter 18, BIOFILMS, W. G. Characklis and K.C. Marshall editors, John Wiley and Sons, November.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1643

PROJECT TITLE: Measurement of Soil Structure, Water Movement, and Solute Transport Using Computed Tomography

PERFORMING ORGANIZATION: University of Missouri - Columbia

PRINCIPAL INVESTIGATORS: R. L. Peyton and S. H. Anderson

START: September 1988

FINAL REPORT RECEIVED: March 1991

ABSTRACT:

Structured, heterogeneous porous media present serious problems in predicting water and contaminant movement. X-ray computed tomography (CT) applied to soil cores was found to be an effective tool for non-destructively characterizing small-scale heterogeneity and for measuring small-scale water and solute movement through soil. At a pixel scale of 0.7 x 0.7 mm, autocorrelation and partial autocorrelation functions suggest that soil bulk density is characterized by a first-order autoregressive system in undisturbed soil cores. At a pixel scale of 0.1 x 0.1 mm, macropore diameters can be estimated down to 0.5 mm with a mean error of 3%; errors decrease to less than 1% for diameters greater than 3.0 mm. Perimeter fractal and area fractal methods were used to characterized the spatial variability of soil bulk density using the large data sets produced by CT. Both methods produced unique fractal dimension relationships for forest, field, and uniformly-packed soil cores. CT was used to quantify the effect of an artificially-created macropore in a uniformly-packed soil core on the infiltration wetting front. The distribution of solute breakthrough times within a soil core was computed from CT data collected during a solute breakthrough experiment. These data were used to produce a relative frequency distribution of velocities within the core.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB99-168971

PUBLICATIONS:

Anderson, S. H., Peyton, R. L, and Gantzer, C. J., 1990, Evaluation of constructed and natural coil macropores using X-ray computed tomography: Geoderma, 46: 13-29.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1646

PROJECT TITLE: Expedite Changes in Water Use, Hydrologic Criteria, and Market Transactions

PERFORMING ORGANIZATION: New Mexico State University

PRINCIPAL INVESTIGATOR: S. C. Nunn

START: September 1988

FINAL REPORT RECEIVED: April 1991

ABSTRACT:

Data on transactions costs and time delays involved in satisfying New Mexico's administrative criteria for determining hydrological impacts of proposed changes in water use were collected and analyzed. The data revealed that most such proposals are processed cheaply and expeditiously, and that hydrologic factors were not a significant determinant of either time delays or costs. Institutional analysis and interview suggested that the lack of definition of hydrologic criteria may be based on the lack of defined social criteria for the public objectives of state water management. Some approaches to giving content to these public objectives are explored, particularly regional water planning and public education. As an example of an approach to the latter, a computerized model of the State Engineer's Office (SEO) criteria which links the two-dimensional finite difference hydrologic model of the Mimbres basin to the SEO criteria for the basin was produced, with a user manual which is accessible to water right holders or interested policy analysts. Some policy applications of this model are explored.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-242875

PUBLICATIONS:

Nunn, S. C., 1990, Transfers of New Mexico water: A survey of changes in place and/or purpose of use, 1975-1987: In proceedings of the 34th Annual New Mexico Water Conference, Water Resources Research Institute Report No. 248, New Mexico State University, Las Cruces, New Mexico, p. 83.

Nunn, S. C., 1990, Distinguishing technical from political transactions costs in water exchanges: the case of New Mexico: In proceedings of the Third Symposium on Social Science in Resource Management, May 16-19, Texas A. & M. University, p. 158.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1649

PROJECT TITLE: Benefit Estimation in Ground-water Protection by Local Decision Makers

PERFORMING ORGANIZATION: Cornell University

PRINCIPAL INVESTIGATOR: D. J. Allee

START: September 1988

FINAL DATE RECEIVED: November 1990

ABSTRACT:

A contingent valuation survey was conducted on households in 12 communities. Each relies on ground water for public water supply and seven have experienced contamination in the past ten years. Large differences in willingness-to-pay for increased water supply protection were found, both within and across communities. Differences in household willingness-to-pay were found between groups that have, and groups that have not, experienced contamination. Regression analysis revealed income, experience of a contamination incident, perception of water supply safety, and perception of potential sources of contamination, significantly affect household willingness-to-pay for increased protection. Personal interviews with key informants ascertain perceptions of the resources, and attitudes to contamination and protection. Content analysis provided evidence that contamination has little impact on adoption of local ordinances to protect sources. Source protection was the result of interaction between hydrogeologic characteristics, local perception of those characteristics, state and local institutional organization, and perceived level of community growth. Content analysis also supplied five water supply protection concepts which were used, along with willingness-to-pay in a cognitive mapping technique. Results suggest contingent value information has an impact on key informant's understanding of the causal relationships between the six concepts.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-141929

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1654

PROJECT TITLE: Deterministic and Stochastic Evaluation of Nitrate-Nitrogen Leaching from Soils with Dual-Pore Systems in Karst Regions

PERFORMING ORGANIZATION: Pennsylvania State University

PRINCIPAL INVESTIGATOR: D. E. Baker

START: September 1988

FINAL REPORT RECEIVED: August 1991

ABSTRACT:

Field experiments were conducted to study the movement of water and contained solutes in soil with dual pore systems under saturated conditions. The experiments were conducted on Duffield silt loam and Clarksburg silt loam soils in southeastern Pennsylvania. Infiltration rates and bromide transport were measured. Bromide tracer experiments showed that the distribution of bromide in the soil profile was highly variable. About 50 percent of applied bromide moved vertically and leached below the root zone via large continuous soil macropores at saturated conditions. Results from lysimeter experiments indicated that the soil water NO_3-N concentration in porous cup lysimeter samples generally exceeds the concentration in samples collected from zero-tension lysimeters.

The LEACHP model was used for the 1987 and 1988 growing seasons for the control, two broadcast ammonium nitrate and three manure treatments. Simulated results were compared with results from field experiments. Measured nitrogen uptake and nitrate storage in the soil profile, as well as mineralization and nitrification rates, were higher in 1987 than in 1988. The simulated nitrogen uptake agreed in all cases with measured nitrogen removal by crops. LEACHP model was used to simulate the amount of bromide leached in each infiltrometer. The model predicted an average of 52 percent leaching below the root zone and a significant correlation ($r=0.88$) was found between the measured and model predicted results.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB92-118397

PUBLICATIONS:

Simmons, K. E., 1990, Nitrogen management for corn production and water quality in southeastern Pennsylvania: Ph.D. Thesis, Pennsylvania State University, p. 177.

Simmons, K. E. and Baker, D. E., 1991, The effect of long-term manure applications on the response of corn yield and soil and water NO_3-N to nitrogen applications: In: A. B. Bottcher (ed.) Proceedings of Conference on Environmentally Sound Agriculture, Orlando, Florida, April 16-18, Florida Cooperative Extension Service, Institute of Food and Agriculture Sciences, University of Florida, Gainsville, Florida, p. 596-604.

Jabro, J. D., Lotse, E. G., Simmons, K. E., and Baker, D. E., 1991, A field study of macropore flow under saturated conditions using a bromide tracer: Accepted for publication in Soil and Water Conservation Journal.

Grant, S. A., Jabro, J. D., Fritton, D. D., and Baker, D. E., 1991, A stochastic model of infiltration which simulates macropore soil-water flow: Accepted for publication in Water Resources Research Journal.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1655

PROJECT TITLE: The Paleoclimatic History of Devils Lake, North Dakota

PERFORMING ORGANIZATION: University of New Hampshire

PRINCIPAL INVESTIGATOR: W. B. Lyons

START: September 1988

FINAL REPORT RECEIVED: March 1991

ABSTRACT:

We have analyzed a series of sediment, porewater, and ground-water samples in and around the Devils Lake, N.D. region in order to: (1) establish a short term (for example ~500yr) climatic record, (2) determine the relationship between hydrologic forcing and the lake's biological response, (3) calculate a chemical budget for the lake waters and (4) understand the influence of the Spiritwood Aquifer on the overall lake system. Our data indicate that the sediments of the lake provide a detailed paleohydrologic and paleobiological record of the lake. Biogenic silica correlates extremely well with changes in lake level and therefore represents an extremely sensitive indicator of the paleohydrology of the drainage basin. Time series analyses of the sediment data demonstrates a close correlation between in-situ lake biological activity and the ~11yr sun spot cycle. Our geochemical budget of the lake suggests that the lake sediments are an important source of solutes to the lake waters especially at high stand periods. The ground-water analyses show that the major recharge to the Spiritwood Aquifer is probably from winter precipitation.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-168963

PUBLICATIONS:

Lent, R. M., Lyons, W. B., Dibb, J. E., and Showers, W., J., 1990, High precision paleoclimatic and paleobiologic records from sediments of Devils Lake, North Dakota: Abstract, Spring AGU Meeting.

Lent, R. M., 1991, The geochemistry and climatic history of Devils Lake Basin, North Dakota: Ph.D. Dissertation, University of New Hampshire, Durham, New Hampshire.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1656

PROJECT TITLE: Precipitation Regime Changes Resulting from Climatic Changes

PERFORMING ORGANIZATION: North Carolina State University

PRINCIPAL INVESTIGATORS: D. H. Moreau and P. J. Robinson

START: September 1988

FINAL REPORT RECEIVED: June 1991

ABSTRACT:

The relationship between precipitation events and atmospheric circulation in the southeastern United States is investigated to provide information potentially useful in assessing the impact of climate change on water resources. There are about 130 precipitation events annually, evenly divided by season. Most events are less than 1 hour long and give less than one tenth inch of rain. The Appalachian Mountains have longer storms, and south Florida shorter, sharper ones, than the regional average. When continental-scale atmospheric circulation patterns create airflows predominantly from the southwest, areas east of the mountains have long, heavy, and variable events, while western events have the opposite character. Predominantly westerly flow gives a reverse trend. A Geographic Information System was used to develop and test methods for display and analysis of the spatial distribution of event precipitation. These methods potentially provide a means of assessing the influence of topography on precipitation events.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-206656

PUBLICATIONS:

Henderson, K. G. and Robinson, P. J., 1990, Relationships between continental-scale circulation and rainfall event attributes in North Carolina: Paper presented at the Forty-fifth Annual Meeting of the Southeastern Division, Association of American Geographers, November 18-20, Columbia, South Carolina.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1658

PROJECT TITLE: Geochemical Processes in a Modern Coastal Ground-water Mixing Zone and Their Hydrologic and Petrologic Implications

PERFORMING ORGANIZATION: University of Virginia

PRINCIPAL INVESTIGATORS: J. Herman and A. Randazzo

START: September 1988

FINAL REPORT RECEIVED: July 1991

ABSTRACT:

Mixing of seawater and freshwater in a coastal carbonate aquifer system has produced a chemically reactive environment for diagenetic processes. Mineral dissolution, alteration, and precipitation are common processes occurring in the ground-water mixing zone. The dynamic flow characteristics of hydrologic systems are dependent upon the effects of diagenesis on porosity and permeability. Our current understanding of the hydrogeologic and petrologic implications of geochemical processes in this environment is incomplete.

This study tests the general hypothesis that carbonate diagenesis in the ground-water mixing zone of a coast is a dynamic and critical process in the development of porosity and permeability. The specific objectives are to (1) establish the geochemistry and petrology of a modern mixing zone, (2) quantify the geochemical reactions that yield the current composition of the mixing zone, and (3) relate these geochemical processes to the petrologic and hydrogeologic evolution of a coastal limestone aquifer.

The Floridan aquifer, at a locality along the coast of Pasco County, Florida, was investigated in detail. The mixing zone water composition evolved in a step-like pattern of increasing salinity with depth. All water samples were super-saturated with respect to stoichiometric calcite but the aquifer itself was more soluble than pure calcite. Cavernous zones were encountered during drilling,

and the genetic relationship between them and the ground-water salinity gradient remains an intriguing question. Observed paragenesis of the limestone includes marine micritization and cementation, meteoric mineralogical stabilization, dissolution enhancement of porosity, and phreatic calcite cementation. Dolomite was encountered in the lower part of the core, and most of it is calcium-rich.

OBTAINABLE FROM: National Technical Information Service
Order Department
Springfield, Virginia 22161
U.S.A.

ORDER NUMBER: PB91-234716

PUBLICATIONS:

Randazzo, A. F. and Herman, J. S., 1990, Geochemical development of karst in the Florida Peninsula: International Symposium on Hydrogeologic Processes in Karst Terranes, Antalya, Turkey, October.

Wicks, C. M., Herman, J. S., Randazzo, A. F., and Jee, J. L., 1990, The influence of limestone stability on the interpretation of geochemical processes occurring in the saltwater-freshwater mixing zone: Geological Society of America, Annual Meeting, Dallas, Texas, November.

Jee, J. L., Randazzo, A. F., Wicks, C. M., and Herman, J. S., 1991, Profile of a modern coastal mixing zone in Tertiary carbonate rocks of the Floridan Aquifer, Pasco County, Florida: American Association of Petroleum Geologists, Annual Meeting, Dallas, Texas, April.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1721

PROJECT TITLE: Treatment of Membrane Surfaces with Oriented Monolayers for Improved Renovation of Impaired Water

PERFORMING ORGANIZATION: Eastman Kodak Company

PRINCIPAL INVESTIGATOR: L. M. Speaker

START: August 1989

FINAL REPORT RECEIVED: June 1991

ABSTRACT:

Antifouling technology (AFT) for separatory membranes was initially demonstrated in 1981. This research was designed to test AFT against humates and alternative foulants, enhancing the fundamental understanding of fouling and fouling propensity. We surface-modified membranes with Langmuir-Blodgett (LB) films (oriented monomolecular films) and monitored responses of selectivities and throughputs to challenges. Our materials bank included 18 surfactants, five different types of separatory membranes, and 15 likely foulants. At least 300 membranes were surface-modified and their permeation characteristics followed in more than 150 computer-controlled 23-h challenges, in most cases with aqueous sodium humate. LB-system vibration problems may have compromised the quality and fouling resistance of some coatings. However, both selectivities and cumulative permeate volumes of membranes LB-coated with 11-perfluorohexyl undecanoic acid, 11-perfluoroheptyl undecanyl pyridinium bromide, and 11-perfluorooctyl undecanyl pyridinium bromide were superior to those of controls, indicating that LB treatment had simultaneously increased both selectivity and fouling-resistance. More data is being analyzed; as the database expands, we expect to contribute to the mechanisitic understanding of fouling and fouling prevention, as well as developing selection criteria for the best (least fouling) combinations of AFT treatment, membrane, and feed stream.

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COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1722

PROJECT TITLE: Extension of USEPA Method 531 for the Analysis of Several Classes of Nitrogenous and Aromatic Pesticides in Ground Water by Postcolumn UV Photolysis

PERFORMING ORGANIZATION: University of Florida

PRINCIPAL INVESTIGATOR: A. H. Moye

START: June 1989

FINAL DATE RECEIVED: January 1991

ABSTRACT:

The primary objective of this research was to expand the number of pesticides that can be analyzed in ground water at trace levels by extending the USEPA Method 531 that now covers N-methyl carbamate and carbamoly oxime pesticides to include several other classes of nitrogenous and aromatic pesticides by postcolumn ultraviolet (UV) photolysis. On-line photolysis with a 2-watt mercury lamp in a Teflon tube knitted photoreactor was used to replace the conventional alkaline hydrolysis solution that is metered in postcolumn and the high performance liquid chromatographic(HPLC) separations were optimized for several pesticides on reversed phase columns. Postcolumn on-line photolysis and/or photolysis followed by OPA-MERC reagent derivatization was sufficient for generation of fluorophores leading to enhanced fluorescence detection in HPLC for monitoring various pesticide residues in ground water. The fluorescence detector sensitivity was optimized by selection of lamp type, photoreactor designs, photolytic solvents, and derivatization. The chromatographic resolutions and peak capacity were maximized by proper choice of analytical columns and elution solvent programming. Limits of detections less than 1 *ug*/L were obtained for several classes of nitrogenous and aromatic pesticides in ground water by direct injection of 0.4 mL filtered water samples onto reversed phase analytical columns. The method was validated by determining percentage recoveries for various fortification levels,

standard deviations for replicate analysis, and storage stability. The postcolumn UV photolysis and fluorometric detection provided sensitive, selective, and direct analysis of many pesticides in ground water at ppb concentrations that were, until now, not capable of being analyzed.

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PUBLICATIONS:

Patel, B. M., Moye, H. A., and Weinberger, R., in press, Postcolumn UV photolysis for formation of fluorophores from nitrogenous pesticides and fluorescence detection in liquid chromatography: Talanta, International Journal of Analytical Chemistry.

Patel, B. M., Moye, H. A., and Weinberger, R., 1990, Formation of fluorophores from nitrogenous pesticides by photolysis and reaction with OPA-2-Mercaptoethanol for fluorescence detection in liquid chromatography: Journal of Agricultural and Food Chemistry, v. 38, p. 126-134.

COMPLETED PROJECT

GRANT NUMBER: 14-08-0001-G1736

PROJECT TITLE: Facilitating Voluntary Transfer of Bureau of Reclamation - Supplied Water

PERFORMING ORGANIZATION: University of Colorado

PRINCIPAL INVESTIGATOR: L. J. MacDonnell

START: June 1989

FINAL REPORT RECEIVED: August 1991

ABSTRACT:

The importance of redefining the role of the Federal reclamation system in meeting the contemporary water needs of the western states prompted this project. The primary objective of the project was to examine the effect of Federal law, policy, and procedures on the transfer of water supplies from Federal storage facilities to new users. By evaluating the water transfer experience in 14 case studies representing a broad cross-section of Federal reclamation projects, the research sought to identify the type and nature of Federal requirements found to impede transfers, to evaluate the basis and purpose of these factors, and to consider possible changes to facilitate valuable transfers. The report is in two volumes: the first contains the general analysis and recommendations; the second contains detailed case studies.

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