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ABSTRACT

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17a. Descriptors
*Research, *Information Transfer, *Training, *Louisiana, Microbial Degradation, Organic Compounds, Environmental Effects, Organic wasted, Clay Permeability, Flood, Stochastic Analysis, Dispersion, Adsorption, Dioxin, PCB's.

17c. COWRR Field & Group

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Send to:
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Abstractors Donald D. Adrian, Dir.
Institution Louisiana State University-LWRRI

FISCAL YEAR 1985 PROGRAM REPORT

Louisiana Water Resources Research Institute
2401-A CEBA Building
Louisiana State University
Baton Rouge, Louisiana

Report NO. G-1020-01

Fiscal Year 1985 Program Report

Grant Number 14-08-0001-G-1020

for

U.S. Department of Interior
Geological Survey

by

Louisiana Water Resources Research Institute
Louisiana State University
Baton Rouge, LA 70803
Donald Dean Adrian, Director
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ABSTRACT

The focus of the Fiscal Year 1985 Louisiana Water Resources Research Institute Program was to support both applied and theoretical projects. The applied projects were of immediate value to Louisiana, while theoretical projects concurrently assisted in the solution of long range problems.

Water resources problems were addressed relating to flood technology, ground water, water resources planning, and hazardous waste contamination. Project 02 identified the effects of chlorinated hydrocarbons on the water transmission properties of cohesive deposits which are common to a large portion of Louisiana's industrial area. Project 03 initiated biodegradation studies of hazardous chemical waste including PCB and Dioxin. Techniques which had enhanced the degradation of chlorinated hydrocarbons were not effective with dioxin. Project 04 involved using a thermal stratification model to evaluate the design and operation of a proposed flood control reservoir. Project 05 evaluated a groundwater model as a management aid in planning for lignite mining in northwestern Louisiana. The model was used to develop strategies which would enable lignite miners to minimize the adverse effects of their operations on groundwater quality. Project 06 utilized entropy to determine multivariate distributions of flood variables given limited data or information. These distributions were tested using real-world flood data.

WATER PROBLEMS AND ISSUES OF LOUISIANA

Water resources problems within the Southern Plains Region (Louisiana, Arkansas, Texas, Oklahoma and New Mexico) have been identified as a result of a survey conducted by the National Association of Water Institute Directors (NAWID) during 1986. The problems are identified in Table 1.

Of the problems which have been identified by NAWID the highest priority for research in Louisiana has been assigned to the following research topics:

* Management of surface water supplies,
* Ground water quality control, especially that research related to the fate of toxic materials,
* Aquifer restoration techniques, and disposal and treatment systems, and
* Legal and institutional issues.

These areas were assigned the highest priority for research because:

* Louisiana has been subject to severe flooding problems due to the flooding of the Mississippi River which drains 40% of the lower continental United States,
* Flooding from other rivers in the state continues to be a problem,
* Flooding from hurricanes is a severe problem for coastal areas,
* The flat topography of Louisiana results in floods causing damage over wide areas,
* Toxic and hazardous wastes have been identified at a number of locations as ground water pollutants,
* Louisiana has an extensive petrochemical industry which has been associated with toxic and hazardous wastes generation,
* The geology and topography of Louisiana make it easy for chemical spills to pollute groundwater,
* Ground water is used extensively as a source of water for individual homes and municipalities.

TABLE I. Water Research Needs Identified for the Southern Plains Region by the National Association of Water Institute Directors in 1986. The research needs are not listed by priority.

RESEARCH TOPIC	SUBTOPIC
1. Ground Water Quality Control	Sources of toxic materials Fate and transport of chemicals Salinity management Aquifer restoration techniques Disposal and treatment systems
2. Surface Water Quality Control	Sources of toxic materials Salinity management Watershed management for erosion and pollution control Eutrophication Disposal and treatment system
3. Management of Surface Water Supplies	Conjunctive surface and ground water management Floodwater control Flood prediction Agricultural water conservation Land use/hydrology interaction Drought prediction and management Watershed management for rainfall use efficiency Water reuse Utilization of brackish waters
4. Management of Ground Water Supplies	Conjunctive ground and surface water supplies Techniques for parameter measurement
5. Political and Economic Issues	Water allocation and reallocation Water values for alternate uses Flood damage assessment
6. Legal and Institutional Issues	Conflict resolution among competing users Conservation incentives Wildlife protection incentives Water demand forecasting Ground water management Constraints to surface water management
7. Ecological, Health and Environmental Relationships	Wetland hydrology Impact of chemicals on wildlife Effect of adjoining, land use on coastal and shoreline water uses Effect of chemicals in water on human health

Other water resources problems are important but the Water Resources Research Institute does not have enough funds to address these problems at this time. The problems include those associated with wetlands. Louisiana has vast areas of wetlands, it being stated that it contains 40% of the nation's wetlands. The wetlands are vulnerable as they overlie many gas and oil deposits. To develop the gas and oil deposits canals are dredged, exposing the wetlands to changes in the circulation pattern of salt and fresh water. Erosion is promoted by the altered flow regimes and fish and wildlife are affected. The economic value of wetlands is not yet well understood, making them vulnerable to misuse. Part of the problem in establishing a value for wetlands is that many of the benefits which accrue from their preservation are captured by others than the landowner. The landowner may give up economic benefits while preserving wetlands and is unlikely to obtain any economic benefits from the value of fish which were fed from the wetlands and were caught by fishermen in the Gulf of Mexico.

Coastal problems are of major importance in Louisiana. The coastal terrain is flat. A small increase in the sea level or a small amount of land subsidence results in the coast line receding. While the sea level is gradually increasing due to melting polar ice, land subsidence is more pronounced. Part of the subsidence is thought to be associated with the relatively young age of the sedimentary deposits which are typical of Louisiana. The geologically young sedimentary deposits will undergo an extended period of consolidation. An additional part of the subsidence is associated with withdrawal of oil, gas and water. The net result is a severe coastal erosion problem. Various figures are presented, but there is agreement that between 30 to 50 square miles of Louisiana coast disappear into the Gulf of Mexico each year.

Water resources planning is an unmet need of the state. The current fiscal crisis of the state in which the deficit is running into the hundreds of millions of dollars per year emphasizes the need for water resources planning and the establishment of priorities. Instead, the fiscal crisis is leading to the slashing of state water resources agency budgets in a desperate attempt to cope.

The trend of the federal government to impose cost sharing obligations on the state and local governments as a condition for receiving federal water resources grants is developing a need for long range planning in the state. How should the state finance its portion of the cost of water resources projects? What share of the project cost should

be financed by bonds as opposed to financing by current revenue? How should the repayment obligations be allocated between direct project beneficiaries and indirect project beneficiaries? What priority should the state give to water resources project development when it is faced with a high unemployment rate, a declining economy, and a citizenry which has to solve immediate crises rather than speculate about long range, abstract concepts? These are but a few of the concerns and questions which are impacting state decision makers as they wrestle with questions of financing the state's share of water resources projects.

The issue of water resources planning and management and state financing of cost sharing obligations touches on the problem of water resources institutions. Does the state have the institutional structure to handle these problems or is this structure still evolving? This is a problem area which the LWRRI could address as part of its research program if it were perceived as a priority topic for research by state agencies.

Water quality standards of the state may very well be ready for updating. An example is the nitrogen to phosphorus ratio which involves elements which are nutrients when one addresses eutrophication, while certain nitrogen species have a potential role in toxicity to fish and aquatic life as well as a role in human health problems. Yet the nitrogen to phosphorus level is not an adequate standard with which to address toxicity problems of fish and aquatic life or the problems of methemoglobinemia (blue babies) in humans. A reexamination of the state's water quality standards is in order.

The previous discussion of Louisiana's water resources problems is not an exhaustive listing of all of the problems and issues. Indeed, the identification and perception of problems is in a dynamic state due to external natural forces of climate and weather, i.e., recall the concern for the Southwestern U.S. drought of 1986; legislation, i.e., The Water Resources Development Act of 1986; global, i.e., the declining oil prices of 1985 and 1986; local i.e., the proposed Darlington Reservoir; and statewide, i.e., the current fiscal crisis. Due to these factors a continuous reassessment of the water resources problems of the state is necessary.

PROGRAM GOALS AND PRIORITIES

The LWRRI funded five projects of outstanding quality. These projects addressed critical problems identified in the Institute's Five-Year Plan as well as in the Southern Plains Region list of priority problems for water resources research. The research projects addressed some of the critical water quality concerns and the techniques to quantify and alleviate these problems as well as addressing one of the long range problems of the state that is related to too much water, the problem of flooding.

The Institute's cooperative program addressed these specific concerns. Five projects were initiated to address problems of flooding, aquifer protection, water resources management and water quality. A summary of these projects is presented and their relevance is briefly reviewed.

Project 02: "The Transport of Chlorinated Hydrocarbons in Saturated Cohesive Deposits of Southern Louisiana"

The disposal of various organic wastes generated by chemical and oil industries heralds a potential danger to water resources of the State. An understanding of the rate of movement of these contaminants is needed for development of remedial measures and mitigation of hazards. This project is designed to assess the effect of various chlorinated hydrocarbons on geotechnical properties of soft cohesive deposits in the Baton Rouge-New Orleans area. Permeability, adsorption and dispersion coefficients will be determined for various concentrations of these contaminants. This project complements ongoing studies at Louisiana State University on biological and hydrological aspects of environmental control.

Project 03: "Fate of PCB and Dioxin in Louisiana's Aquatic Environment"

PCB and dioxin have been found to enter Louisiana's aquatic environment. These organic compounds are toxic to aquatic life and potentially detrimental to humans. Currently, insufficient information exists on the fate and effect of these organics in Louisiana's aquatic environment. This study will elucidate some of the factors affecting the persistence of PCB and dioxin in aquatic environment. It will provide a comprehensive understanding of the fate and effect of PCB and dioxin by determining their adsorption-desorption in soils and exchange between sediment and overlying layer. The results will be useful to Louisiana's Department of Environmental Quality and those concerned with the fate of toxic organics in aquatic systems.

Project 04: "Prediction of Hydrothermal Regimes"

The State of Louisiana experiences severe flooding during heavy rains. The Amite River basin is currently being considered for flood control measures. In particular, construction on a flood control reservoir near Darlington, Louisiana, is under study. This reservoir, if constructed, will impose potentially major impacts on the quality of water in the Amite River downstream of the dam and in Lake Maurepas. These impacts must be addressed to assure best usage of the receiving waters to minimize damage to recreational areas and fisheries as well as in the reservoir itself. This study will develop a mathematical model to predict water quality of the reservoir, and thereby assess the environmental impacts to be expected in the reservoir.

Project 05: "A Groundwater Model for Pre-operational and Post-operational Management of Lignite Mining"

The development and exploitation of vast coal reserves in the U.S. will play a crucial role in the development of alternative energy sources in the future. Louisiana's coal resources are of low rank (i.e., lignite and sub-bituminous). One of the critical factors influencing the full scale development of lignite is the effect on water resources. Special management tools are needed for pre-operational and post-operational planning and management of mining activities to protect and conserve the quantity and quality of groundwater in the mining area. This study proposes to develop such tools by using a discrete kernel approach. The tools developed will be of considerable value to the State agencies which are charged with the authority to manage, control and monitor the quality of groundwater. These tools will also be applicable to problems of contamination of groundwater associated with hazardous waste sites, sanitary landfills, improper land disposal of waste, salt water intrusion, leachates from mining activities, accidental chemical spills, etc.

Project 06: "A Multivariate Stochastic Analysis of Flood Magnitude, Duration and Volume"

A wide spectrum of civil works require frequency distributions of flood magnitude, duration and volume. The bulk of hydrologic literature available on stochastic modeling of floods gravitates around deriving a frequency distribution of the largest annual flood peak. By comparison, very limited research has been reported on frequency analysis of concurrent flood duration and volume. Thus, the problem is one of determining multivariate distributions of these flood variables from which their marginal distributions can be deduced. Furthermore, current observations of sufficient length on magnitude, duration and volume may not be available but some of their statistics may be known. The multivariate distributions must therefore be derived with this limited information. The project is proposed to accomplish precisely that. The procedure to be developed will also be applicable to stochastic analysis of droughts, groundwater pollution, sediment transport, biochemical pollution, streamflow forecasting, etc. The results will be useful to practicing hydrologists, field engineers, planners and managers at the local, State and federal levels.

RESEARCH PROJECT SYNOPSES

Synopses of research projects funded by the Institute are provided in the following order:

Project number: 02

1. Transport of Chlorinated Hydrocarbons through Saturated Cohesive Deposits in Southern Louisiana, Dr. Yalcin Acar, Associate Professor of Civil Engineering, LSU, Principal Investigator.

Project number: 03

2 Fate of PCB and Dioxin in Louisiana's Aquatic Environment, Dr. Ronald DeLaune, Assistant Professor of Wetland Soils and Sediments, and Dr. William H. Patrick, Jr., Boyd Professor and Director of Wetland Soils and Sediments Laboratoty, LSU, Co-Principal Investigators.

Project number: 04

3. Prediction of Hydrothermal Regimes in the Proposed Darlington Reservoir, Dr. Stephen Field, Associate Professor of Civil Engineering, LSU, Principal Investigator.

Project number: 05

4. A Groundwater Model for Pre-operational and Post-operational Management of Lignite Mining, Dr. Tissa Illangasekare, Assistant Professor of Civil Engineering, LSU, Principal Investigator.

Project number: 06*

5. A Multivariate Stochastic Analysis of Flood Magnitude, Duration and Volume, Dr. Vijay P. Singh, Professor of Civil Engineering, LSU, Principal Investigator.

Synopsis

Project Number: 02

Start: 7/1/85 (actual)
End: 6/30/86 (expected)

Title: Transport of Chlorinated Hydrocarbons through Saturated Cohesive Deposits in Southern Louisiana

Investigators: Acar, Y. B., Louisiana State University, Baton Rouge, Louisiana

COWRR: 5B

Congressional District: District 6

Descriptors: Chlorinated Hydrocarbon, Chemical Wastes Pollutants, Contamination, Clays, Louisiana, Permeability Coefficient, Dispersion Coefficient, Adsorption

Problem and Research Objectives: This study will assess the effects of various chlorinated hydrocarbons on the geotechnical properties of cohesive deposits in Baton Rouge-New Orleans industrial area. The effect of a selected chlorinated hydrocarbon on permeability, adsorption and dispersion coefficient will be determined by testing undisturbed specimens of the deposit obtained from a boring at a representative location in the area.

Methodology: Regional geology and geotechnical properties of Baton Rouge-New Orleans industrial district will be reviewed. A site will be selected that appropriately represents these deposits. Borings will be opened at selected locations through the funding provided by a local geotechnical engineering company. Undisturbed soil specimens will be retrieved. After a logging of the borehole and classification of the deposits at the site, permeability tests will be conducted to determine the permeability, adsorption and diffusion coefficient of the deposits when permeated with low level concentrations of the selected chlorinated hydrocarbon.

Principal Findings and Significance: Borings are completed. Consolidation permeameters are designed and constructed. Tests related to the performance of the equipment is completed. Trichloroethlene is selected as the contaminant. Analytical methods for evaluating the test results have been selected and developed. Currently permeation tests are continuing.

Publications and Professional Presentations:

Acar, Y. B., Haider, L., and Edil, T. B., "Barrier Systems in Waste Disposal," Proceedings of the Third International Symposium on Environmental Management for Development Countries, August 1986, Istanbul, pp. 1-44.

M.S. Thesis:

Haider, Laique, "Transport of Chlorinated Hydrocarbons in Saturated Cohesive Deposits of Southern Louisiana," (expected February, 1987).

Training Accomplishments

Academic Disciplines	Academic Level				
	Undergraduate*	Master's Degree*	Ph.D. Degree*	Post-Ph.D.*	Total*
Engineering - Agricultural - Civil - Environmental	2	1			3
Biology					
Ecology					
Fisheries, Wildlife and Forestry					
Agronomy					
Chemistry					
Hydrology					
Resources Planning					
Law					
Economics					
Geography					
Other (specify)					
TOTAL	2	1			3

* Insert the number of individuals participating in the projects financed by the award.

Synopsis

Project Number : 03

Start: 8/85

End: 7/86

Title : Fate of PCB and Dioxin in Louisiana's Aquatic Environment

Investigators : DeLaune, R.D. and Patrick, W.H., Jr., Laboratory for Wetland Soils and Sediments, Louisiana State University

COWRR : 5B

Congressional District : Sixth

Descriptors : PCBs, dioxin, toxic organics, Louisiana, microbial degradation

Problem and research objectives : A number of toxic organics including PCBs and dioxins are entering Louisiana's aquatic environment in increasing amounts. There is insufficient scientifically-based evidence available to predict persistance of these compounds in Louisiana's rivers, streams and bayous. Additional information is needed to address, and possibly reduce, the adverse effects of toxic organics on the quality of surface water.

The research objectives of this project were to:

(1). Quantify the persistence and/or rate of mineralization of selected PCBs and dioxin currently found in Louisiana's aquatic environment.

(2). Evaluate methods of enhancing mineralization of these toxic organics in soils and sediments.

Methodology : Microbial mineralization rates of a ^{14}C-labeled polychlorinated biphenyl (PCB) mixture (Aroclor 1254) and a ^{14}C-labeled dioxin (2,3,7,8-tetrachlorodibenzo-p-dioxin) were determined in Louisiana soil and sediment under controlled pH and redox conditions. Mineralization rates were inferred from the activity of $^{14}CO_2$ evolved from the sediment suspensions. Non-ionic surfactants, alternate carbon sources, and sequential environmental conditions were investigated as methods of enhancing mineralization of toxic organics.

Principal findings and significance : They are as follows:

(1). Mineralization rates of Aroclor 1254, a common PCB contaminant, were higher under moderately aerobic conditions than under highly aerobic or anaerobic conditions in contaminated freshwater lake sediment. These results suggest that PCBs are more amenable to mineralization under moderate redox conditions where facultative microorganisms persist.

(2). Mineralization rates of 2,3,7,8-TCDD were negligible under aerobic or anaerobic conditions in Louisiana soil or freshwater sediment. This result suggests that 2,3,7,8-TCDD will remain stable in Louisiana soil or sediment over long periods of time.

(3). Surfactants, alternate carbon sources, and sequential redox conditions did little to enhance mineralization rates of 2,3,7,8-TCDD in Louisiana soil or freshwater sediment. Techniques which have previously been shown to enhance degradation of chlorinated hydrocarbons were not effective with dioxin.

Publications : Pardue, J.H., R.D. DeLaune, and W.H. Patrick, Jr. 1986. Effect of sediment pH and oxidation-reduction potential on PCB mineralization in contaminated lake sediment. Environ. Toxicol. & Chem. In Review.

M.S. Thesis : Pardue, J.H. 1986. Factors affecting mineralization and attenuation of PCBs and dioxin under controlled soil conditions and in land application systems. Marine Sciences. Louisiana State University.

Training Accomplishments

Academic Disciplines	Academic Level				
	Undergraduate*	Master's Degree*	Ph.D. Degree*	Post-Ph.D.*	Total*
Engineering - Agricultural - Civil - Environmental					
Biology	2				2
Ecology					
Fisheries, Wildlife and Forestry					
Agronomy					
Chemistry					
Hydrology					
Resources Planning					
Law					
Economics					
Geography					
Other (specify) (Marine Science)		1			1
3 TOTAL	2	1			3

* Insert the number of individuals participating in the projects financed by the award.

Synopsis

Project No. 04 Start: 10/85
End: 10/86

Title: Prediction of Hydrothermal Regimes in the Proposed Darlington Reservoir

COWRR: 02H Congressional District No. : 06

Descriptors: Thermal Stratification, Hydrodynamics, Mathematical Model, Reservoirs, Water Quality

Investigator: Stephen D. Field, Louisiana State University, Baton Rouge

Problem and Research Objectives:

Various portions of the State of Louisiana undergo severe flooding problems during heavy rain seasons. In particular, the Amite River is about to undergo comprehensive study for the implementation of a flood control Reservoir on the River near Darlington, LA. This project addressed the preliminary step of hydrothermal modeling needed to evaluate the projected water quality in the proposed Darlington Reservoir. The overall objective was lead towards the development of a mathematical model to project the water quality of the proposed Reservoir, and thereby assess the environmental impacts to be expected in the Reservoir. The project effort applied a thermal stratification model to evaluate the design and operation of the proposed Darlington Reservoir. Development and application of this model is the key step in evaluating the potential ramifications to downstream areas of the Amite River and Lake Maurepas.

Methodology

Data was collected on the proposed Darlington Reservoir to determine the proposed morphometry of the system. Based on the densiometric Froude number, the selection of a one-dimensional model, CETHERMR1, was made. This model, obtained from the US Army Corps of Engineers, Vicksburg, MS, was converted from CDC to IBM code for use on LSU system computers.

Model calibration required the development of a data base on a surrogate system. The surrogate system was chosen based on its proximity to the proposed Reservoir (i.e. similar meteorological influences), similar morphological characteristics (mean depth, surface area, etc.), and the available data base for model development. A flood control reservoir near Meridian, MS (approximately 140 miles northeast of the proposed Reservoir site), was used for calibration. After model calibration the model was used to simulate the proposed Darlington Reservoir system.

Principal Findings and Significance:

The major benefit and goal of this study is the establishment of a hydrothermal model to assess the design and operation of the proposed Darlington Reservoir. The application of this model to evaluate the extremes in hydraulic operation of the flood control Reservoir will assist in determining the potential water quality of the Darlington Reservoir and the possible effects of releases downstream. The extremes in hydraulic operation of the Reservoir can severely influence the stratification patterns of the Reservoir, resulting in a direct effect on water quality through mediation of biochemical rates, vertical transport of materials and algal productivity. This physical model of stratification will serve as the key element to drive a water quality model which will be more fully developed in further research.

The final phase of this work was the actual simulation of the Darlington Reservoir under hydraulic operation and point of withdrawal. Projections are made as to thermal stratification patterns within the Reservoir and potential impacts downstream. Results for the data available indicate that the Darlington Reservoir typically will stratify during the months of June through September. This stratification pattern will result in isolated bottom Reservoir waters being released during summer months. Operation of the Reservoir and maintenance of water quality (e.g. dissolved oxygen levels) downstream must consider the biogeochemical processes that will occur in the Reservoir, affecting the released bottom water quality.

Publications and Professional Presentations:

N/A

M.S. Theses:

N/A

Ph.D. Dissertations:

N/A

Training Accomplishments

Academic Disciplines	Academic Level				
	Undergraduate*	Master's Degree*	Ph.D. Degree*	Post-Ph.D.*	Total*
Engineering - Agricultural - Civil - Environmental	1		1	1	3
Biology					
Ecology					
Fisheries, Wildlife and Forestry					
Agronomy					
Chemistry					
Hydrology					
Resources Planning					
Law					
Economics					
Geography					
Other (specify)					
TOTAL	1		1	1	3

* Insert the number of individuals participating in the projects financed by the award.

Synopsis

Project Number: 05

Start: 07/01/85
End: 08/31/86

Title: A Groundwater Model for Pre-operational and Post-operational Management of Lignite Mining.

Investigator: Illangasekare, Tissa H., Louisiana State University Baton Rouge (currently at University of Colorado, Boulder)

COWRR: 05(G) Congressional District: Sixth

Descriptors: groundwater management, groundwater pollution, mathematical models, solute transport

Problem and research objectives: The exploitation of the Nation's vast coal reserves will play a crucial role in the development of alternatives to the depleting oil and natural gas reserves. Most of the identified resources are located in the northern Great Plains provinces in Montana, Wyoming and North Dakota. Smaller deposits but of considerable local importance are found in Rocky Mountain states, and Pacific and Gulf Coast provinces. The lignite bearing formations in the Gulf Coast region are found in Texas, Louisiana, Arkansas, Alabama, and Mississippi. The belts of near-surface and deep-basin lignite cut across the northwestern parts of Louisiana. The development and exploitation of the resources is of both regional and local importance to Louisiana.

Typical operations of surface-mining of lignite involve the removal of the top soil and overburden to access the deposit. After the coal is mined, the overburden is replaced and the land reclaimed Leachable chemicals formed during the mining process get dissolved in the water passing through the reclaimed site. This water will eventually reach the water table thus affecting the quality of groundwater.

The task of management of groundwater systems against potential contamination involves the design of pre-operational strategies of mining and post-operational strategies of reclamation of the affected land. The objective of this research was to develop a management oriented analytical tool which will model the transport of leachates or solutes in the saturated layers of aquifers. Specifically, a management oriented distributed parameter model was developed which has the capabilities to: 1) simulate the transport of a contaminant introduced directly onto the aquifer or at a boundary, and 2) evaluate different remediation or reclamation schemes for a contaminated aquifer.

Methodology: Two basic requirements for a model to qualify as a management tool is its ease of use and cost effectiveness. In general, for the accurate numerical solution of the partial differential equations of water flow and solute transport, short computation time steps have to be used. At the same time, the slow movement of groundwater and the solutes required the simulations to be performed for a long time horizon to evaluate the levels of contamination at points farther away from the mining site. The development of a model required the simultaneous solution of the partial differential equations governing the flow of water in the saturated zone of the aquifer and the advection-dispersion equation which governs transport of a conservative solute. In the model developed, the transient velocity field needed for the solution of the advection-dispersion equation is computed using the discrete kernel approach (a response matrix procedure). The kernel coefficients (or Green's functions) are generated once for the nonhomogeneous aquifer by solving the linearized partial differential equation of groundwater flow using a finite difference scheme. The velocity distribution corresponding to given set of excitations is obtained by performing a simple convolution. The advection-dispersion processes are modelled by using a particle tracking method based on the method of characteristics. Instead of strictly using particles, influence areas representing the concentration of particles were routed along the flow paths.

The developed model was verified by comparing with analytical solutions for simple cases and with results from using two popularly used USGS solute transport models.

Principal findings and significance: The comparison with analytical solutions and the other existing transport models showed that the model based on the discrete kernel approach gives comparable computing accuracies with significant improvement in simulation costs. Because of the adaptation of the influence area approach for particle tracking, the model gave much more accurate solutions in comparison to other method of characteristics models. Also, the same accuracy (or even better in some cases) of solution was obtained by using a smaller number of particles in the tracking scheme. The very marginal computing costs involved in the use of the developed discreet kernel approach model make it suitable for management oriented applications. Because of the linearization of the governing flow equation, it is possible to superpose analytical solutions for the head distribution in regions where a refined velocity field is needed for accurate particle tracking. Also, the decoupling of the two governing equations makes it possible to easily incorporate, reactive, ion exchange, precipitation, decay and biological processes into the model. Research is currently in progress to build these capabilities into the model.

Publications and professional presentations:

Abstracts submitted:

1) Illangasekare, T.H. and Y.C. Yap, A contaminant transport model for aquifer reclamation design and management, National Water Well Association Conference on "Solving Groundwater Problems with Models", Denver, Colorado, February 10-12, 1986.

2) Illangasekare, T.H. and Y.C. Yap, A Discret Kernel solute transport model for groundwater quality management, ASCE National Conference on Hydraulics and Engineering Hydrology Symposium, Williamsburg, Virginia, August 3-7, 1987.

A journal paper is currently under preparation to be submitted to Water Resources Research.

M.S. theses:
Yap, Y.C., a discrete kernel groundwater quality management model, Department of Civil Engineering, Louisiana State University, Baton Rouge Louisiana (expected to be completed in December, 1986)

Ph.D. dissertations: None

Training Accomplishments

Academic Disciplines	Academic Level				
	Undergraduate*	Master's Degree*	Ph.D. Degree*	Post-Ph.D.*	Total*
Engineering - Agricultural - Civil - Environmental		1			1
Biology					
Ecology					
Fisheries, Wildlife and Forestry					
Agronomy					
Chemistry					
Hydrology					
Resources Planning					
Law					
Economics					
Geography					
Other (specify)					
TOTAL		1			1

* Insert the number of individuals participating in the projects financed by the award.

Synopsis

Project Number: 06

Start: 10/1/85
End: 9/30/86

Title: A Multivariate Stochastic Analysis of Flood Magnitude, Duration and Volume

Investigators: Singh, Vijay P., Department of Civil Engineering, Louisiana State University, Baton Rouge, LA 70803-6405.

COWRR: 2E

Congressional District: 6th

Descriptors: Floods analysis, entropy, probability distribution, multivariate analysis, stochastic analysis.

Problem and research objectives: A wide spectrum of civil works require frequency distributions of flood magnitude, duration and volume. The bulk of hydrologic literature available on stochastic modeling of floods is devoted to deriving a frequency distribution of the largest annual flood peaks. By comparison, very limited research has been reported on frequency analysis of concurrent flood duration and volume. Furthermore, current observations of sufficient length on magnitude, duration and volume may usually not be available. Thus, the objective of this research is to determine multivariate distributions of these variables with limited data or information.

Methodology: The procedure developed in this study employs entropy which is a numerical measure of uncertainty associated with representing a random variable. By maximizing entropy subject to the given information (or constraints) on the flood variables, the least biased probability distributions, joint as well as marginal, are derived. These distributions are then tested using real-world flood data from a number of rivers in the U.S.A.

Principal findings and significance: The results of this study can be summarized as follows: (1) Entropy and principle of maximum entropy can be applied to derive any probability distribution expressible in direct form. (2) Most probability distributions, used in hydrology, have been derived. (3) The procedure of derivation yields a method of distribution parameter estimation. (4) The entropy method unifies the extreme value analysis and time series analysis. Therefore, it is possible to reconstruct the past records and forecast the future records. (5) The entropy method has been extended to design of hydrologic networks and sediment and pollutant transport. (6) The entropy method has been found to be comparable with other methods of parameter estimation.

Publications and professional presentations: The following publications have resulted from this study:

Arora, K. and Singh, V. P., 1986. An evaluation of entropy method for estimating parameters of the EV1 distribution. Proceedings, International Symposium on Flood Frequency and Risk Analyses, held

May 14-17, at Louisiana State University, Baton Rouge, LA, in press.

Arora, K. and Singh, V. P., 1986. On statistical intercomparison of EV1 estimators using Monte Carlo simulation. submitted to Advances in Water Resources.

Fiorentino, M., Singh, V. P. and Arora, K., 1986. On the two component extreme value distribution and its point and regional estimators. Proceedings, International Symposium on Flood Frequency and Risk Analyses, held May 14-17, at Louisiana State University, Baton Rouge, LA, in press.

Fiorentino, M., Arora, K. and Singh, V. P., 1986. The two-component extreme value distribution for flood frequency analysis: another look and derivation of a new estimation method. submitted to Water Resources Research.

Jain, D. and Singh, V. P., 1986. An evaluation of some empirical methods for flood frequency analysis: 1. Analysis and validation. Completion Report, Louisiana Water Resources Research Institute, Louisiana State University, Baton Rouge, LA.

Jain, D. and Singh, V. P., 1986. An evaluation of some empirical methods for flood frequency analysis: 2. Data and computer programs. Completion Report, Louisiana Water Resources Research Institute, Louisiana State University, Baton Rouge, LA.

Jain, D. and Singh, V. P., 1986. Comparison of some flood frequency distributions using empirical data. Proceedings, International Symposium on Flood Frequency and Risk Analyses, held May 14-17, at Louisiana State University, Baton Rouge, LA, in press.

Krstanovic, P. F. and Singh, V. P., 1986. A multivariate stochastic flood analysis using entropy. Proceedings, International Symposium on Flood Frequency and Risk Analyses, held May 14-17, at Louisiana State University, Baton Rouge, LA, in press.

Rajagopal, A. K., Teitler, S. and Singh, V. P., 1986. Some new perspectives on maximum entropy techniques in water resources research. Proceedings, International Symposium on Flood Frequency and Risk Analyses, held May 14-17, at Louisiana State University, Baton Rouge, LA, in press.

Singh, V. P., 1985. On the Log-Gumbel distribution. Hydrology Journal of the IAH, Vol. VIII, No. 4, pp. 34-42.

Singh, V. P., 1986. On Application of the Weibull distribution in Hydrology. Water Resources Management, in press.

Singh, V. P., 1986. On the extreme value (EV) type III distribution for low flows. submitted to Hydrological Science Journal.

Singh, V. P. and Krstanovic, P. F., 1986. A stochastic model for sediment yield using the principle of maximum entropy. submitted to Water Resources Research.

Singh, V. P. and Krstanovic, P. F., 1986. Spatial design of rainfall networks using entropy. accepted for inclusion in Proceedings, International Conference on Water Resources Needs and Planning in Drought Prone Areas, to be held December 6-12, in Khartoum, Sudan.

Singh, V. P. and Krstanovic, P. F., 1986. A stochastic model for sediment yield and phosphorous loading. submitted to Journal of Environmental Quality.

Singh, V. P. and Rajagopal, A. K., 1987. Some recent advances in application of the principle of maximum entropy (POME) in hydrology. accepted for inclusion in Proceedings, International Symposium on Water for the Future, to be held April 6-11, in Rome, Italy.

Singh, V. P. and Rajagopal, A. K., 1986. A new method of parameter estimation for hydrologic frequency analysis. submitted to Hydrological Science and Technology.

Singh, V. P. and Singh, K., 1986. Application and derivation of three parameter lognormal distribution by POME for flood analysis. submitted to Water Resources Bulletin.

M.S. Theses: (1) A Comparative Evaluation of Methods of Frequency Analysis and Estimation of Parameters, thesis, by D. Jain, May 1986, Department of Civil Engineering, Louisiana State University, Baton Rouge, LA. (2) A Comparative Evaluation of Estimators of Commonly Used Flood Frequency Models, under preparation by K. Arora, Department of Civil Engineering, Louisiana State University, Baton Rouge, LA.

Ph.D. dissertations: (1) Entropy Theory and its Application to Flood Analysis, under preparation by P. F. Krstanovic, Department of Civil Engineering, Louisiana State University, Baton Rouge, LA.

Training Accomplishments

Academic Disciplines	Academic Level				
	Undergraduate	Master's Degree	Ph.D. Degree	Post-Ph.D.	Total
Engineering - Agricultural - Civil - Environmental					
Biology					
Ecology					
Fisheries, Wildlife and Forestry					
Agronomy					
Chemistry					
Hydrology		2	1		3
Resources Planning					
Law					
Economics					
Geography					
Other (specify)					
TOTAL		2	1		3

INFORMATION TRANSFER ACTIVITIES

The Louisiana Water Resources Research Institute (LWRRI) has been engaged and continues to engage in a variety of activities which help transmission of research results to the user. The Institute deems this activity as vital to accomplish its mission. Specifically, the Institute requires each principal investigator to prepare a detailed document at the conclusion of his research project which also serves as a completion report. Most of the completion reports are published by the Institute as technical reports. These reports are made available to the public free of charge while the initial supply is available and later they are available, for a nominal cost to cover reproduction charges. Individual users, private companies, government organizations and others may receive them upon request. Many of the reports have been in high demand. If a particular user wants to use the results or methodology of a research project, then the Institute helps bring the principal investigator and the user together and assists the two in every possible way in their efforts to bridge the gap between research and practical application.

The Institute is called upon, from time to time, to identify individuals with certain specialized skills to perform a given task. In addition , the Institute offers advice on water related problems to individual users, local and state government organizations, as well as private companies. One of the more frequently occurring requests from the public involves identification of laboratories which can perform analyses of water samples.

To help the user keep abreast of current research and technological developments, the Institute encourages and sponsors/co-sponsors seminars,lectures, workshops, conferences, or symposia on topics of current and future interest. These forums provide unique opportunities

to the researcher, the educator, the user, and the manager to be together and engage in fruitful discussions.

During 1986 LWRRI was a primary sponsor of two major events. These were:

1. "Ground Water Contamination in Louisiana - Issues and Answers," February 27, 1986. The seminar was attended by over 150 people. Other sponsors included the Civil Engineering Department and Hazardous Waste Research Center. This seminar was very successful and additional seminars are planned for subsequent years.
2. "International Symposium on Flood Frequency and Risk Analysis," May 14-17, 1986. This symposium was attended by over 200 people from many different countries.

LWRRI has received some requests that it serve a role in helping identify, organize and present additional short courses to water resources professionals.

TRAINING ACCOMPLISHMENTS

The number of individuals participating in projects financed in part with grant funds are shown by fields of study and training levels.

Training Category	Training Level				
	Undergraduate	Graduate			
		Master's Degree	Ph.D. Degree	Post Ph.D.	Total
Engineering					
Agricultural					
Chemical					
Civil	2	2			4
Environmental	1		1	1	3
Industrial					
Biology	2				2
Ecology					
Fisheries, Wildlife and Forestry					
Agronomy					
Chemistry					
Hydrology		2	1		3
Resource Planning					
Law					
Economics					
Geography					
Geology					
Other					
Specify - Marine Science		1			1
TOTAL	5	5	2	1	13

COOPERATIVE ARRANGEMENTS

Interdisciplinary investigations in water resources are coordinated by the Water Resources Research Institute which is administered by the College of Engineering. The Institute administers the federal and state cooperative research and training programs as instituted by the Water Resources Research Act of 1984 (P.L. 98-242) under the auspices of the United States Geological Survey in the United States Department of the Interior.

The general objective of the Water Resources Research Institute is to bring the intellectual and physical resources of the several colleges and universities of Louisiana to bear on the solution of the increasingly important scientific, technical, economic, institutional, and management problems associated with quanity and quality aspects of the development, use, and conservation of our water resources. The Institute also has the responsibility for the dissemination of technical information which is developed from research projects. Graduate assistantships are funded through research projects.

Louisiana: As mailed to Florey

Louisiana Water Resources Research Institute
LOUISIANA STATE UNIVERSITY AND AGRICULTURAL AND MECHANICAL COLLEGE
BATON ROUGE · LOUISIANA · 70803
504/388-8508

Mr. Quentin Florey
Program Officer
U.S.G.S.
425 National Center
Reston, VA. 22092

July 31, 1987

Dear Mr. Florey:

Attached are the revisions requested for the Louisiana Water Resources Research Institute's FY 85 Annual Report. Should other changes be necessary, please call.

Sincerely,

Brenda Kelly

Brenda Kelly
Assistant Director
LWRRI

Enclosure

Selected Water Resources Abstracts
Input Transaction Form

3. Accession No.
W

4. Title
Fiscal Year 1985 Program Report

7. Author(s)

10. Project No.

9. Organization
Louisiana State University, Baton Rouge, LA
Louisiana Water Resources Research Institute

11. Contract/Grant No.
14-08-0001-G-1020

15. Supplementary Notes
Program Report G-1020-01, March 1987, 30 p., 0 figs, 28 refs.

16. Abstract

ABSTRACT

The focus of the Fiscal Year 1985 Louisiana Water Resources Research Institute Program was to support both applied and theoretical projects. The applied projects were of immediate value to Louisiana, while theoretical projects concurrently assisted in the solution of long range problems.

Water resources problems were addressed relating to flood technology, ground water, water resources planning, and hazardous waste contamination. Project 02 identified the effects of chlorinated hydrocarbons on the water transmission properties of cohesive deposits which are common to large portion of Louisiana's industrial area. Project 03 initiated biodegradation studies of hazardous chemical waste including PCB and Dioxin. Techniques which had enhanced the degradation of chlorinated hydrocarbons were not effective with dioxin. Project 04 involved using a thermal stratification model to evaluate the design and operation of a proposed flood control reservoir. Project 05 evaluated a groundwater model as a management aid in planning for lignite mining in northwestern Louisiana. The model was used to develop strategies which would enable lignite miners to minimize the adverse effects of their operations on groundwater quality. Project 06 utilized entropy to determine multivariate distributions of flood variables given limited data or information. These distributions were tested using real-world flood data.

17a. Descriptors
*Research, *Information Transfer, *Training, *Louisiana, Microbial Degradation, Organic Compounds, Environmental Effects, Organic wasted, Clay Permeability, Flood, Stochastic Analysis, Dispersion, Adsorption, Dioxin, PCB's.

17c. COWRR Field & Group

18. Availability

Send to:
Water Resources Scientific Information Center
GEOLOGICAL SURVEY, Mail Stop 425
U.S. DEPARTMENT OF THE INTERIOR
Reston, Va 22092

Abstractors Donald D. Adrian, Dir.
Institution Louisiana State University-LWRRI

WRSIC 102 (REV. JULY 1985)

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