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Hydraulic Research in the United States and Canada, 1976

Hydraulic Research in the United States and Canada, 1976

Edited by

Pauline H. Gurewitz

Institute for Basic Standards
National Bureau of Standards
Washington, D.C. 20234

U.S. DEPARTMENT OF COMMERCE, Juanita M. Kreps, Secretary

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ABSTRACT

Current and recently concluded research projects in hydraulics and hydrodynamics for the years 1975-1976 are summarized. Projects from more than 200 university, industrial, state and federal government laboratories in the United States and Canada are reported.

Key words: Fluid mechanics; hydraulic engineering; hydraulic research; hydraulics; hydrodynamics; model studies; research summaries.

ACKNOWLEDGEMENT

The editor gratefully acknowledges the valuable assistance of Dr. Gershon Kulin in the preparation of this document.

PREFACE

This publication first appeared in 1933 as "Hydraulic Research in the United States" in answer to a need to keep hydraulicians aware of pertinent current activity in research laboratories throughout the United States and Canada. With the exception of a few World War II years, it was published annually through 1966, after which publication became biennial. In 1972 the title was changed to "Hydraulic Research in the United States and Canada."

The National Bureau of Standards appreciates the cooperation of the more than 200 organizations which have contributed to this issue their summaries of hydraulic and hydrologic research and of other fluid mechanics research of interest and usefulness to hydraulicians. These reporting organizations are listed beginning on page vii. Although efforts are made to solicit reports from all laboratories whose work comes to our attention, the National Bureau of Standards cannot assume responsibility for the completeness of this publication. We must depend in the last analysis upon reporting laboratories for the completeness of the coverage of their own programs, and upon new laboratories engaged in pertinent research to bring their activities to our attention.

Detailed information regarding the research projects reported here should be obtained from the correspondent listed under (c) or immediately following the title and address of the organization reporting the work. The National Bureau of Standards does not maintain a file of publications, reports or other detailed information on research projects reported by other laboratories. It is of course understood that laboratories submitting reports on their work will be willing to supply additional information to properly qualified inquirers.

Readers of "Hydraulic Research in the United States and Canada" can find related information in the "Water Resources Research Catalog," prepared by the Science Information Exchange of the Smithsonian Institution for the Office of Water Resources Research, U.S. Department of the Interior. Information on that publication can be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. (See also Key to Projects on next page.)

CONTENTS

KEY TO PROJECTS

The project summaries are grouped in three sections: (1) U. S. university, state and industrial laboratories, (2) U. S. Government laboratories, and (3) Canadian laboratories. Within each section the source laboratories are listed alphabetically (see List of Contributing Laboratories on page vii) and are numbered sequentially using the first three digits of the identification number.

(a) Project number and title

In the thirteen-digit identification number, e.g., 129-01111-000-00, preceding each title, the second (five-digit) group, e.g., 01111, is the project number. Once assigned, this number is repeated in each issue for identification purposes until the project is completed. In this issue the numbers 09776 and above are projects being reported for the first time. Numbers folowed by W, e.g. 0122W, identify projects which are included here by title only and are completely summarized in "Water Resources Research Catalog." See Preface.

(b) Project conducted for

Only out-of-house sponsors are listed here. Absence of an entry indicates in-house support.

(c) Correspondent

Where there is no entry here, refer to the correspondent cited directly following the title and address of the reporting laboratory.

(d) Nature of Project

Basic or applied; theoretical, experimental; thesis, etc.

(e) Description of Project

(f) Present Status

Absence of an entry here implies that the project was in an active status at time of submission.

(g) Results

In many continuing projects this section contains only results obtained since the previous issue of "Hydraulic Research in the United States and Canada." For completeness, readers are encouraged to consult earlier issues and/or publications listed under (h).

(h) Publications

For the continuing projects, only publications since the last issue are generally listed. Older publications are listed when there have been no new publications since the last issue or when a project is being reported for the first time. For completeness, readers are encouraged to consult earlier issues.

LIST OF CONTRIBUTING LABORATORIES

- - - - - - - - - - - - - - - - -

PROJECT REPORTS FROM UNIVERSITY, STATE, AND INDUSTRIAL LABORATORIES

AEROSPACE CORPORATION, P.O. Box 92957, Los Angeles, Calif. 90009. Dr. A. Mager, Vice President and General Manager, Engineering Science Operations.

001-07917-050-00

STUDIES OF SWIRLING FLOWS

(*d*) Theoretical; applied research.
(*e*) Investigation of free and confined swirling flows with particular emphasis on the breakdown phenomena.
(*h*) **Steady, Incompressible, Swirling Jets and Wakes,** A. Mager, *AIAA J.* **12,** 11, 1974.

UNIVERSITY OF AKRON, Department of Civil Engineering, Akron, Ohio 44325. Dr. A. L. Simon, Department Head.

002-0415W-810-00

DEVELOPMENT OF LINEARIZED SUBHYDROGRAPH METHOD OF URBAN RUNOFF DETERMINATION

(*c*) Dr. S. Sarikelle, Associate Professor.
(*e*) See Water Resources Research Catalog **11**, 4.0032.

002-09953-360-47

LABORATORY AND FIELD EVALUATION OF ENERGY DISSIPATORS AT CULVERT OUTLETS

(*b*) U.S. and Ohio Department of Transportation.
(*c*) Dr. S. Sarikelle, Associate Professor.
(*d*) Experimental, theoretical and applied research.
(*e*) Development of energy dissipator consisting of prefabricated modular units for culvert and storm drain outlets. Relationships between scour patterns and flow characteristics are investigated by laboratory tests. Prototype performance is determined by field studies.
(*g*) Prototype installation of the first version of the modular energy dissipator has been accomplished.
(*h*) **Field and Laboratory Evaluation of Energy Dissipators,** S. Sarikelle, A. L. Simon, *Interim Report I*, Hydraulics Lab., Univ. of Akron, Feb. 1975.
Field and Laboratory Evaluation of Energy Dissipators, S. Sarikelle, A. L. Simon, *Interim Report II*, Hydraulics Lab., Univ. of Akron, Feb. 1977.

UNIVERSITY OF AKRON, Department of Mechanical Engineering, Akron, Ohio 44325. Dr. Rudolph J. Scavuzzo, Department Head.

003-09776-010-14

FINITE ELEMENT ANALYSIS OF INVISCID, SUBSONIC COMPRESSIBLE FLOW, WITH APPLICATIONS TO BOUNDARY LAYER COUPLING AND INVERSE COMPUTATIONS

(*b*) U.S. Army Research Office, Durham.
(*c*) Dr. P. M. Gerhart, Assoc. Professor; R. Chima.
(*d*) Analytical, basic research for Ph.D. thesis.
(*e*) Inviscid subsonic compressible flows are to be computed in primitive variable form via the finite element method. Coupling with existing turbulent boundary layer methods, and inverse (design) applications, will be investigated.

003-09777-140-00

TURBULENT AND LAMINAR INTERNAL OR EXTERNAL FLOWS WITH HEAT TRANSFER

(*c*) Benjamin T. F. Chung, Assoc. Professor.
(*d*) Theoretical basic research for Ph.D. and M.S. theses.
(*e*) Development of mathematical models for various complex transport processes.
(*h*) **A Transient Surface Renewal and Penetration Model for Turbulent Forced Convection from a Plate,** B. T. F. Chung, L. C. Thomas, *Proc. 5th Intl. Heat Transfer Conf.* **2,** 124 (1974).
Unsteady Heat Transfer for Turbulent Boundary Layer Flow with Time Dependent Wall Temperature, L. C. Thomas, B. T. F. Chung, *J. of Heat Transfer, Trans. ASME* **96,** 117 (1974).
An Analysis of Heat Transfer in Turbulent Annular Flow, B. T. F. Chung, L. C. Thomas, *Proc. 10th Ann. Southeastern Sem. on Thermal Science* (1974).
Turbulent Heat Transfer for Pipe Flow With Prescribed Fluxes at Walls and Uniform Heat Sources in the Stream, B. T. F. Chung, L. C. Thomas, *J. Heat Transfer, Trans. ASME* **96,** 430 (1974).
A Surface Rejuvenation Model for Turbulent Convective Transport–An Exact Solution, L. C. Thomas, P. Gingo, B. T. F. Chung, *Chem. Eng. Sci.* **30,** 1239 (1975).
Heat Transfer for Turbulent Annular Flow of High Prandtl Number Fluids, B. T. F. Chung, L. C. Thomas, Y. Pang, *ASME Paper 75-HT-39*.
Transient Convective Heat Transfer for Laminar Boundary Layer Flow With Effects of Wall Capacitance and Resistance, C. C. Wang, B. T. F. Chung, L. C. Thomas, *J. Heat Transfer, Trans. ASME*, (in press).
An Analysis of Transient Heat Transfer for Steady Turbulent Flow Over A Flat Plate, L. C. Thomas, V. Nagpal, B. T. F. Chung, *Proc. 12th Ann. Southeastern Sem. on Thermal Sciences*, (1976).

UNIVERSITY OF ALASKA, Institute of Water Resources, Fairbanks, Alaska 99701. Dr. Robert F. Carlson, Director.

004-09952-300-54

HYDRAULIC MECHANISM OF AUFEIS GROWTH

(*b*) National Science Foundation.
(*d*) Theoretical and field investigation; applied research.
(*e*) A field study over three winters was carried out to measure the variability of pressure beneath an ice cover. Theoretical analysis to correlate the observed pressure fluctuations with climatic variables was performed using Time Series techniques.
(*g*) Large pressure fluctuations in the unfrozen water beneath the ice cover occur. These fluctuations appear to be related to ambient temperatures; the pressures increase as

the ambient temperatures increase, however, there is a lag of several days between the two series.

(*h*) **Analysis of Stream Aufeis Growth and Climatic Conditions,** D. L. Kane, R. F. Carlson, *3rd Natl. Hydrotechnical Conf.*, Quebec, Canada, May 30-31, 1977.

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ARGONNE NATIONAL LABORATORY, Energy and Environmental Systems Division, 9700 So. Cass Ave., Argonne, Ill. 60439. Dr. John D. Ditmars, Manager, Water Resources Section.

005-09778-440-52

GREAT LAKES POLLUTANT TRANSPORT PROCESSES

(*b*) U.S. Energy Research and Development Administration.
(*c*) Dr. Kim D. Saunders.
(*d*) Theoretical and field investigation; basic and applied research.
(*e*) The spatial and temporal variation in nearshore (< 10 km offshore) currents and the near-bottom currents in central Lake Michigan are investigated. Data from this program and others are employed in evaluating the ability of numerical lake circulation models to predict the circulations and to estimate residence times for pollutants in both the nearshore zone of southwestern Lake Michigan and in the southern basin of the lake. The near-bottom currents are measured in support of sediment resuspension studies.
(*g*) Based on existing data, no numerical models tested have been able to predict the lake circulations with any degree of reliability. An empirical linear transfer function model has been able to account for about 80 percent of the variance caused by local winds. Pollution residence times are being computed at present.
(*h*) **Preliminary Verification of Numerical Circulation Models for Lake Michigan,** J. H. Allender, M. J. Berger, K. D. Saunders, *Proc. Symp. for Modeling of Transport Mech. in Oceans and Lakes*, Scientific Rept., Environment Canada (1977).
Nearshore Currents at Point Beach Wisconsin, 1974-1975, K. D. Saunders, L. Van Loon, C. Tome, W. Harrison, *Argonne Natl. Lab. Rept. ANL/WR-76-1*, Mar. 1976.
Nearshore Currents in Southern Lake Michigan (June-November, 1975), K. D. Saunders, L. S. Van Loon, *Argonne Natl. Lab. Rept. ANL/WR-76-2*, May 1976.
Modification of Braincon 381 Current Meter for Identification of Start/Stop Frame of Film, *Exposure* **4,** 4, pp. 6-9 (1976).
Thermograph Records of Upwelling Events in Southwestern Lake Michigan, K. D. Saunders, L. S. Van Loon, *Radiological and Environmental Research Div. Ann. Rept.–Ecology, January-December 1975, ANL-75-60*, Part III (1976).
Review and Appraisal of Numerical Circulation Models for Lake Michigan, J. H. Allender, *Argonne Natl. Lab. Rept. ANL/WR-76-6*, Sept. 1976.

005-09779-870-36

FATE OF REFINERY WASTES/INDIANA HARBOR CANAL

(*b*) U.S. Environmental Protection Agency, U.S. Energy Research and Development Administration, and Illinois Institute for Environmental Quality.
(*c*) Dr. Wyman Harrison.
(*d*) Field investigation; applied research.
(*e*) The transport and dispersion of oil-refinery wastes from the Indiana Harbor Canal into southwestern Lake Michigan are studied in the field using simulated waste and tracers. The wastes and subsurface waters are tagged with rare-earth tracers and dye, and the dispersing plumes are sampled for several days from a vessel. Summer conditions, when the canal outflow enters the lake at the surface, and winter conditions, when the canal outflow sinks below the lake surface, are both investigated.
(*g*) Techniques for tracking and sampling both the floating and sinking plumes and for sample analysis by neutron activation have been developed. Field experiments have been carried out for one floating plume and one sinking plume. Certain wind and circulation conditions during winter appear to direct the canal outflow northward in the lake in the direction of the water treatment plant intakes.
(*h*) **Transport and Dispersion of Oil-Refinery Wastes in the Coastal Waters of Southwestern Lake Michigan (Experimental Design–Sinking-plume Condition),** D. L. McCown, W. Harrison, W. Orvosh, *Argonne Natl. Lab. Rept. ANL/WR-76-4*, July 1976.

005-09780-870-52

SUBMERGED DIFFUSER DISCHARGE ANALYSIS

(*b*) U.S. Energy Research and Development Administration.
(*c*) Dr. John D. Ditmars.
(*d*) Theoretical and field investigation; applied research.
(*e*) Submerged discharges of cooling waters from electric power generation into large bodies of water are investigated. Models for the prediction of the temperature fields of the resulting thermal plumes are evaluated. Prototype data are collected by Argonne at several sites on the Great Lakes using a towed thermistor cable, ranging system, and data acquisition system onboard a small boat. The three-dimensional temperature structure data gathered are employed for model evaluation. Ambient water temperature, circulation, and wind are monitored during plume mapping.
(*g*) Thermal plumes for relatively shallow-submergence discharges for the Zion Nuclear Power Station and the D. C. Cook Nuclear Power Plant on Lake Michigan have been mapped and studied. Field investigations have been initiated at the multiport diffuser of the J. A. FitzPatrick Nuclear Power Plant on Lake Ontario. Near-field dilutions at the Zion site have been compared with model predictions, and the effects of current on single and adjacent pairs of discharges at that site have been documented.
(*h*) **Field Studies of the Thermal Plume from the D. C. Cook Submerged Discharge with Comparisons to Hydraulic Model Results,** A. A. Frigo, R. A. Paddock, D. L. McCown, *Argonne Natl. Lab. Rept. ANL/WR-75-3*, May 1975.
Field Studies of Submerged-Diffuser Thermal Plumes with Comparisons to Predictive Model Results, A. A. Frigo, R. A. Paddock, J. D. Ditmars, *Proc. 15th Intl. Conf. on Coastal Engrg.*, Honolulu, July 1976 (in press).
Thermal Plumes from Submerged Discharges at Zion Nuclear Power Station: Prototype Measurements and Comparisons with Model Predictions, R. A. Paddock, A. A. Frigo, L. S. Van Loon, *Argonne Natl. Lab. Rept. ANL/WR-76-5*, July 1976.

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ARIZONA STATE UNIVERSITY, Department of Chemical and Bio Engineering, Tempe, Ariz. 85281. Dr. Castle O. Reiser, Faculty Chairman.

006-08825-250-54

DRAG REDUCING ADDITIVES

(*b*) NSF, ACS-PRF.
(*c*) Dr. Neil S. Berman.
(*d*) Experimental and theoretical basic and applied research.
(*e*) Study of the relationship of flow timescales to high molecular weight polymer solution timescales.
(*g*) Experiments have been conducted showing the effect of molecular weight distribution, time scale distribution and different irrotational and turbulent flow scales.
(*h*) **Drag Reduction Onset for a Random Coil Polymer,** J. Yuen, *M.S.E. Thesis*, Chemical Engrg., Arizona State Univ., Tempe, Ariz., Dec. 1976.
Drag Reduction and Turbulent Production Using Dilute DNA Solutions, S. Elihu, *M.S.E. Thesis*, Chemical Engrg., Arizona State University.

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ARIZONA STATE UNIVERSITY, Department of Mechanical Engineering, Tempe, Ariz. 85281. Dr. Darryl Metzger, Department Chairman.

007-07141-000-00

LAMINAR FLOW BETWEEN CO-ROTATING DISKS

(*c*) Professor Warren Rice.
(*d*) Analytical and experimental; applied research; Doctoral and MSE theses.
(*e*) Development of solutions for flow useful in development and design of multiple-disk turbomachinery; experimental investigation of criteria for transition of laminar to turbulent flow, and experimental confirmation of analytical descriptions earlier obtained.
(*f*) Complete.
(*g*) Indicated by publications.
(*h*) **Calculated Design Data for the Multiple-Disk Turbine Using Incompressible Fluid,** M. J. Lawn, Jr., W. Rice, *J. Fluids Engrg., ASME Trans.* **96,** 1, 3, Sept. 1974.

007-08698-630-00

INVESTIGATION OF AN UNCONVENTIONAL HYDRAULIC GAS COMPRESSOR (TROMPE COMPRESSOR)

(*c*) Professor Warren Rice.
(*d*) Experimental and analytical; basic and applied; Masters thesis.
(*e*) The compressor involves gas bubbles being carried downward in a column of liquid. An analytical model of the compressor involving this type of two-phase flow has been made and calculations of the expected performance have been made using a digital computer. The analytical model has been compared with data from an experimental model of the compressor with excellent agreement.
(*f*) Complete.
(*g*) Performance calculations have indicated that several possible applications areas should be further investigated, including tidal and wave energy recovery and compression of air for power plant load peaking storage.
(*h*) **Performance of Hydraulic Gas Compressor,** W. Rice, *J. Fluids Engrg., ASME Trans.* **98,** 1, 4, Dec. 1976.

007-09931-140-50

MULTIPLE JET ARRAY IMPINGEMENT HEAT TRANSFER CHARACTERISTICS

(*b*) NASA.
(*c*) Professors L. W. Florschuetz and D. E. Metzger.
(*d*) Experimental, applied research, M.S. and Ph.D. theses.
(*e*) Study of flow dynamics and heat transfer on surfaces subjected to impingement from multiple jet arrays.
(*g*) Incomplete.

007-09932-050-70

JET IMPINGEMENT ON ROTATING SURFACES

(*b*) AiResearch Division of the Garrett Corporation.
(*c*) Professor D. E. Metzger.
(*d*) Experimental, applied research, M.S. theses.
(*e*) Study of flow dynamics and heat transfer on rotating surfaces cooled by single and multiple impinging jets.
(*g*) Experiments have been conducted showing a flow regime transition phenomena which significantly affects the heat transfer rate between an impinging jet and a rotating disk.
(*h*) **Heat Transfer Between an Impinging Jet and a Rotating Disk,** D. E. Metzger, L. D. Grochowsky, *ASME Paper No. 76-WA/HT-2*, Dec. 1976.

007-09933-630-88

INVESTIGATION OF MULTIPLE-DISK TURBINES FOR USE WITH GEOTHERMAL STEAM

(*b*) Lawrence Livermore Laboratory.
(*c*) Professors Warren Rice and D. F. Jankowski.
(*d*) Analytical, applied research, M.S. and Ph.D. theses.
(*e*) Laminar flow of very wet steam through the rotor of multiple-disk turbines is calculated using two-phase modeling and finite difference solution methods.
(*f*) Completed.
(*g*) Results indicate that multiple-disk turbines using laminar flow have little or no promise for use with goethermal fluids, but that laminar-flow multiple-disk turbines using steam of higher quality (for other applications) have interesting performance that can now be predicted.
(*h*) **Bulk-Parameter Analysis for Two-Phase Throughflow Between Parallel Corotating Disks,** W. Rice, D. F. Jankowski, C. R. Truman, *Proc. 25th Heat Transfer and Fluid Mechanics Institute*, June 21-23, 1976, Univ. of California, Davis, Calif.
Laminar Throughflow of a Fluid Containing Particles Between Corotating Disks, C. R. Truman, W. Rice, D. F. Jankowski, *ASME Paper No. 76-WA/FE-38.*
Laminar Throughflow of Quality Steam Between Corotating Disks, *ASME Paper No. 76-WA/FE-41.*

007-09934-630-00

HYDRAULIC AIR COMPRESSOR FOR A TIDAL ENERGY RECOVERY

(*c*) Professor Warren Rice.
(*d*) Analytical; applied research; Masters thesis.
(*e*) Existing calculated results, (performance maps) for the hydraulic air compressor are being used, together with performance data for air turbines and models of certain tidal basins, to calculate electrical output that could be obtained from tidal basins with such systems. Economic studies are also to be attempted.'
(*g*) For future comparison, performance models of tidal basins with conventional bulb turbines are now completed and implemented in computer programs.

007-09935-640-50

WAKES FROM BUILDINGS AND NATURAL OBSTACLES

(*b*) National Aeronautics and Space Administration.
(*c*) Professor Earl Logan.
(*d*) Experimental; applied; thesis.
(*e*) Investigation of the response of atmospheric turbulent boundary layers to obstacles of simple geometry.
(*g*) Incomplete.
(*h*) **Wakes from Buildings and Natural Obstacles (Progress Report),** E. Logan, J. Chang, D. K. Melendrez, *Mech. Engrg. Rept. No. ERC-R-77011*, Apr. 1977.

007-09936-210-00

TURBULENT FLOW OVER ROUGHNESS ELEMENTS

(*c*) Professor Earl Logan.
(*d*) Experimental; basic; thesis.
(*e*) Investigation of the response of turbulent pipe flow to ring-type roughness elements.
(*g*) Measurements of profiles of mean velocity, turbulence and Reynolds shear stresses accompanying the transformation from fully-developed smooth to fully-developed rough pipe and channel flow. Same measurements downstream of single roughness elements.
(*h*) **Channel Flow a Smooth-to-Rough Surface Discontinuity with Zero Pressure Gradient,** O. Islam, E. Logan, *J. Fluids Engr.* **98,** 4, pp. 626-634, Dec. 1976.
Response of a Turbulent Pipe Flow to a Change in Roughness, W. D. Siuru, E. Logan, *ASME Paper, Fluids Engrg. Conf.*, June 15-17, 1977.
Response of a Turbulent Pipe Flow to a Change in Surface Roughness, *Ph.D. Dissertation*, Mech. Engr., Arizona State Univ., May 1975.
Measurement and Prediction of Flow Past a Single Roughness Element in Turbulent Pipe Flow, *M.S.E. Thesis*, Mech. Engr., Arizona State Univ., Dec. 1976.

007-09937-000-00

TURBULENT FLOW BETWEEN COROTATING DISKS

(*c*) Professors D. F. Jankowski and Warren Rice.
(*d*) Analytical, applied research, Ph.D. thesis.

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(*e*) Turbulent through flow of a compressible fluid between corotating disks is considered, with expectation of extending solution to case of two phase flow, such as gas-with-particles and/or wet steam.

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UNIVERSITY OF ARIZONA, College of Agriculture, Department of Soils, Water and Engineering, Tucson, Ariz. 85721. Professor Delmar D. Fangmeier.

008-0266W-820-60

GROUNDWATER SUPPLIES

(*e*) For summary, see Water Resources Research Catalog **9**, 2.0033.

008-0267W-840-33

MODELING SOIL WATER MOVEMENT FOR TRICKLE IRRIGATION

(*e*) For summary, see Water Resources Research Catalog **9**, 2.0035.

008-0268W-820-07

MEASUREMENT, PREDICTION AND CONTROL OF SOIL WATER MOVEMENT IN ARID AND SEMI-ARID SOILS

(*e*) For summary, see Water Resources Research Catalog **9**, 2.0036.

008-0269W-840-07

SURFACE IRRIGATION FLOW ANALYSIS THROUGH MODEL STUDIES

(*e*) For summary, see Water Resources Research Catalog **9**, 3.0011.

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AUBURN UNIVERSITY, Department of Civil Engineering, 202 Ramsay Hall, Auburn, Ala. 36830. Dr. Rex. K. Rainer, Professor and Head of Department.

009-09781-340-73

HYDRAULIC MODEL STUDY FOR UNIT 2–FARLEY NUCLEAR PLANT, OPEN CHANNEL SYSTEM

(*b*) Southern Company Services, Inc.
(*c*) Dr. Carl E. Kurt, Asst. Professor.
(*d*) Experimental, design.
(*e*) Build, test and evaluate a 1 to 15 hydraulic model of the Unit 2 Open Channel System. Model flow rates up to 790 gpm are being tested. Flow profiles, characteristics, and velocities are being observed and recorded for various channel configurations. In particular, velocity profiles in the pump intake structure are being carefully evaluated.
(*g*) Preliminary results are leading to a design with significantly improved flow characteristics.

009-09782-860-36

ENGINEERING PERFORMANCE OF THERMOPLASTIC WATER WELL CASINGS

(*b*) U.S. Environmental Protection Agency.
(*c*) Dr. Carl E. Kurt, Asst. Professor.
(*d*) Experimental, applied research; Master's thesis.
(*e*) Provide the engineering data necessary to develop a rational criteria for design of thermoplastic water well casings. This study will minimize the possibility of groundwater contamination caused by well casing failures.

009-09783-860-33

COLLAPSE PRESSURE PREDICTION FOR THERMOPLASTIC WATER WELL CASINGS

(*b*) USDI, Office of Water Research and Technology through Water Resources Research Institute of Auburn University.
(*c*) Dr. Carl E. Kurt, Asst. Professor.
(*d*) Analytical, applied research; Master's thesis.
(*e*) Analytically predict the collapse pressure of thermoplastic water well casings. These hydraulic pressures are caused by groundwater, lateral soil pressure, and the grouting operation.

009-09784-820-30

SUBSURFACE HEAT STORAGE: EXPERIMENTAL STUDY

(*b*) U.S. Geological Survey and the Energy Research and Development Administration.
(*c*) Dr. Fred J. Molz, Alumni Associate Professor.
(*d*) Applied experimental research related to the storage of thermal energy in confined aquifers.
(*e*) A volume of heated water is injected into a confined aquifer by pumping. During the injection-storage-recovery cycle, hydraulic heads and water temperatures are recorded in an array of 14 observation wells. The data is used to determine the efficiency of energy recovery from aquifer storage and as a basis for testing several mathematical models describing the transport of water and heat in an aquifer system.
(*g*) A preliminary experiment resulted in an energy recovery of 70 percent. Computer models operated by the U.S. Geological Survey were able to simulate the head and temperature distributions to a useful extent and predicted a recovery efficiency of 75 percent.

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BATTELLE MEMORIAL INSTITUTE, Columbus Laboratories, 505 King Avenue, Columbus, Ohio 43201. John M. Batch, Director.

010-07969-630-27

HIGH-PERFORMANCE VANE PUMP FOR AIRCRAFT HYDRAULIC SYSTEMS

(*b*) U.S. Air Force, Aero Propulsion Laboratory.
(*c*) D. L. Thomas, Research Engineer.
(*d*) Applied research and development.
(*e*) Demonstrate a variable-displacement two-lobed pressure-compensated hydraulic vane pump capable of operating at 30,000 rpm, 4000 psi, 45 gpm with MIL-H-5606B hydraulic fluid with a design life of over 1000 hours. The pump incorporates two unique concepts: (1) a pivoting-tip vane which provides full hydrodynamic lubrication between the rotating vanes and the stationary cam ring, and (2) a deformable cam ring in which displacement change is achieved by elastically deflecting the member to alter the cam-surface profile. The purpose of the development was to achieve weight reduction for turbine-driven pumps through elimination of gearing and decreased pump size.
(*f*) Completed.
(*g*) The pump was satisfactorily operated at 30,000 rpm, and with various displacements for over 20 hours including 9 hours at 3000 psi. During this series of evaluations there was no significant degradation in flow rate or the condition of parts. The pump was operated for a limited time in a variable-displacement mode controlled with the integral pressure compensator. The pump pressure compensator control system responded to pressure variations but additional development is required to perfect the pressure control. The operational pump was deliverd to the Air Force.
(*h*) A final report was issued in December, 1975, identified as **High Performance Vane Pump for Aircraft Hydraulic** Systems by Battelle's Columbus Laboratories, *Technical Rept. AFAPL-TR-75-94* for Air Force Aero Propulsion Laboratory, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio 45433. Direct request for copies to AFAPL/POP (Attention Mr. K. W. Binns) or to AFAPL/DOE (STINFO).

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BATTELLE MEMORIAL INSTITUTE, Pacific Northwest Laboratories, Water and Land Resources Department, Richland, Wash. 99352. D. B. Cearlock, Department Manager.

011-08797-870-36

AN ASSESSMENT OF MATHEMATICAL MODELS FOR STORM AND COMBINED SEWER MANAGEMENT

(*b*) U.S. Environmental Protection Agency.
(*c*) A. Brandstetter, Sr. Development Engineer.
(*d*) Theoretical investigation; applied research.
(*e*) Twenty-five mathematical models for the nonsteady simulation of urban runoff were evaluated to determine their suitability for the engineering assessment, planning, design and control of storm and combined sewerage systems. The models were evaluated on the basis of information published by the model builders and model users. Seven models were also tested by computer runs using both hypothetical and real catchment data. Most of the models evaluated include the nonsteady simulation of the rainfall-runoff process and flow routing in sewers; a few include also the simulation of waste-water quality, options for dimensioning sewerage system components, and features for realtime control of overflows during rainstorms.
(*f*) Completed.
(*g*) The assessment summarizes the principal features, assumptions and limitations of 25 models, compares numerical test results and computer running costs for several models, and presents the model equations of the tested models. Additional model features are recommended which would enhance or extend model simulation capabilities and use.
(*h*) **Assessment of Mathematical Models for Storm and Combined Sewer Management,** A. Brandstetter, *U.S. Environmental Protection Agency Rept. EPA-600/2-76-175a and 175b*, Aug. 1976, available as *NTIS PB-259 597/AS* (main report and appendices A to E, paper and microfiche copy available) and *NTIS PB-258 644/AS* (appendix F–selected computed printouts, only microfiche copy available).
Evaluation of Mathematical Models for the Simulation of Time-Varying Runoff and Water Quality in Storm and Combined Sewerage Systems, A. Brandstetter, R. Field, H. C. Torno, *Battelle-Northwest Rept. BN-SA-486*, Feb. 1976, and in *Proc. EPA Conf. Environmental Modeling and Simulation*, Cincinnati, Ohio, Apr. 20-22, 1976, *Rept. EPA 600/9-76-016*, pp. 548-552, July 1976.

011-08800-820-52

MOVEMENT OF RADIONUCLIDES THROUGH SOILS

(*b*) Energy Research and Development Administration (Atlantic Richfield Hanford Company).
(*c*) J. R. Eliason, Manager, Resources Systems Section.
(*d*) Experimental and field investigation; applied research.
(*e*) Develop accurate and applicable transport models for describing the movement of radionuclides (and other pollutants) in complex saturated groundwater systems. Both soil chemistry (not discussed here) and hydrology research are included in the program. The latter includes the formulation of algorithms and computer programs for numerical solution of system transmissibility distribution using groundwater potentials and pump test data, and numerical solution to transient behavior of a groundwater system in response to known stresses. The programs are to be capable of analyzing both transient and steady state groundwater systems in significant detail.
(*g*) Algorithms and computer routines were developed for a number of models and codes involving fluid flow in porous media and related transport of contaminants in such media. The Transmissivity Iterative Routine (TIR), was developed for calculating the hydraulic conductivity distribution in heterogeneous aquifers where characterization by field measurement methods alone would be prohibitive in cost. The method is based on the numerical integration of the Boussinesq equation for the hydraulic conductivity along instantaneous streamtubes of flow. The Partially-Saturated Transient Flow Model (PST) was used to test the formulation for simulating isothermal, unsaturated, liquid flow in heterogeneous porous media. The model, when tested, was computationally slow and impractical as a management tool but did demonstrate that the equation could be solved for flow entering relatively dry soils. The Multicomponent Mass Transfer (MMT) Model was developed to predict the movement of radiocontaminants in the saturated and unsaturated sediments of the Hanford Reservation. This model was designed to use the water movement patterns produced by the Hanford unsaturated and saturated flow models coupled with dispersion and soil-waste reaction submodels to predict contaminant motion. Sensitivity studies were made for the existing variable Thickness Transient Groundwater Flow Model.
(*h*) **Partially-Saturated Transient Groundwater Flow Model Theory and Numerical Implementation,** A. E. Reisenauer, D. B. Cearlock, C. A. Bryan, *BNWL-1713*, 1975.
The Transmissivity Iterative Routine–Theory and Numerical Implementation, D. B. Cearlock, K. L. Kipp, D. R. Friedrichs, *BNWL-1706*, 1975.
Variable Thickness Transient Groundwater Flow Model–Theory and Numerical Implementation, K. L. Kipp, A. E. Reisenauer, C. R. Cole, C. A. Bryan, *BNWL-1703*, 1976 (updated).
Multicomponent Mass Transport Model, S. W. Ahlstrom, H. P. Foote, C. R. Cole, R. J. Serne, R. C. Arnett, *BNWL-2127*, 1977 (in progress).

011-09999-860-87

DEVELOPMENT OF WATER QUALITY MODELS FOR MUNICIPAL WATER SUPPLY RESERVOIRS

(*b*) Engineering and Water Supply Department, Adelaide, South Australia.
(*c*) A. Brandstetter, Sr. Development Engineer.
(*d*) Experimental investigation, applied research.
(*e*) Two mathematical water quality models were developed to predict the water quality of water supply reservoirs as a result of changing water quality of the inflowing waters. A simple eutrophication model simulates monthly variations of total and soluble phosphorous in the epilimnion and hypolimnion, and estimates algae and water clarity from total phosphorus. A more complex limnological model simulates daily horizontal and vertical variations of the water temperature, dissolved oxygen, nutrients, algae, salinity and suspended sediments. The eutrophication model was tested with 40 years of data from Lake Washington in Seattle, and the limnological model with two years of data from a water supply reservoir near Adelaide, South Australia.
(*f*) Completed.
(*g*) Testing of the eutrophication and limnological models on Lake Washington, a South Australian reservoir, and other lakes and impoundments in the U.S. indicates that models can reliably predict water quality for a wide variety of limnological conditions. The eutrophication model can be applied with a minimum of data and little cost to predict water quality changes in lakes and reservoirs over many years. The detailed limnological model can then be run to determine more detailed spatial and temporal variations in water quality in years with potentially critical water quality conditions. Used conjunctively, the models provide useful tools for both long-term planning and for short-term assessments of water quality changes resulting from alternate land use and lake management schemes.
(*h*) **Water Quality Models for Municipal Supply Reservoirs, Part 1–Summary, Part2–Model Fromulation, Calibration and Verification, Part 3–User's Manual, and Part 4–Mt. Bold Reservoir Data Acquisition and Evaluation,** A. Brandstetter, R. G. Baca, A. F. Gasperion, A. S. Myhres, Jan. 1977.
Lumped and Distributed Parameter Limnological Models for Deep Lakes and Impoundments, A. Brandstetter, R. G. Baca, A. F. Gasperino, J. K. Shepherd, *Battelle-Northwest Rept. BN-SA-690*, Apr. 1977, and *Proc. 8th Ann. Pittsburgh Conf. Modeling and Simulation*, Apr. 21-22, 1977, Univ. of Pittsburgh (to be published).

011-10000-220-52

COLUMBIA RIVER SEDIMENT/RADIONUCLIDE TRANSPORT MODELING

(*b*) Energy Research and Development Administration.
(*c*) D. W. Dragnich, Manager, Environmental Management Section.
(*d*) Theoretical, field investigation, applied research.
(*e*) A continuing program has been underway to predict sediment and associated transport in the Columbia River through the use of mathematical models. Calculations are made using finite element techniques for solving hydrodynamic and transport equations. Field data have also been collected to obtain additional information for model verification and theoretical developments.
(*g*) Produced two sets of models useful for predicting movements of any pollutant attached to sediments.
(*h*) **Mathematical Simulation of Sediment and Radionuclide Transport in the Columbia River,** Y. Onishi, *BNWL-228*, 1977 (in progress).

011-10001-220-55

MATHEMATICAL MODELING OF SEDIMENT AND RADIONUCLIDE TRANSPORT IN THE CLINCH RIVER, TENNESSEE

(*b*) Nuclear Regulatory Commission.
(*c*) D. W. Dragnich, Manager, Environmental Management Section.
(*d*) Theoretical, field investigation, applied research.
(*e*) The finite element model, SERATRA, has been modified and applied to the Clinch River to solve time-dependent, longitudinal and vertical distribution of sediment and radionuclides. The modeling procedure involves simulating the movements of sediment and the transport of dissolved radionuclides. These results are then input to a model of radionuclides attached to river sediment in order to observe the interaction between sediment and radionuclide movements. Finally, changes in river bed conditions are recorded, including river bottom elevation change, ratio of sand, silt and clay sediment, and distribution of radionuclide concentration in the river bed.
(*g*) Produced a calibrated, verified model for predicting sediment and radionuclide transport in nontidal rivers. The model has been verified using limited radionuclide data. A more detailed field sampling program is underway. Results of this programm will be used for further calibration and verification.

011-10002-870-52

EVALUATION OF GEOHYDROLOGICAL PARAMETERS CONTROLLING TRANSPORT OF CONTAMINANTS BELOW HIGH LEVEL RADIOACTIVE WASTE STORAGE TANKS

(*b*) Energy Research and Development Administration (Atlantic Richfield Hanford Company).
(*c*) S. J. Phillips, Research Scientist.
(*d*) Experimental, applied research.
(*e*) Geohydrologic parameters controlling the flux of contaminants through the partially saturated groundwater domain are being evaluated. Flux and porous media parameters are experimentally determined, and statistical predictions of flux are being made.
(*g*) Characterization of flux controlling parameters and analyses of approximately eighty sediment samples have been accomplished. Preliminary statistical analyses have been used to predict hydraulic conductivity as a function of textural independent variables. An algorithm was developed to determine fluid flux from fluid retentivity and porosity data.

011-10003-870-52

CHARACTERIZATION OF 300 AREA BURIAL GROUNDS

(*b*) Energy Research and Development Administration.
(*c*) S. J. Phillips, Research Scientist.
(*d*) Experimental and field investigation, applied research.
(*e*) Determine the extent and status of radionuclide migration in certain burial grounds in the ERDA Hanford Reservation. Each burial ground is being systematically characterized by comprehensive geologic, geophysical, and biologic surveys. Detailed evaluations of potential mechanisms which may result in migration of the wastes are being conducted and modeled to provide analyses of risks associated with the alternatives of designating these sites for permanent storage and/or removal of the wastes.
(*g*) Initial Site Characterization and Evaluation of Radionuclide Contaminated Solid Waste Burial Grounds, S. J. Phillips, A. E. Reisenauer, W. H. Rickard, G. A. Sandness, *BNWL-2184*, 1977.

011-10004-870-52

MONITORING AND PHYSCIAL CHARACTERIZATION OF UNSATURATED ZONE TRANSPORT

(*b*) Energy Research and Development Administration.
(*c*) S. J. Phillips, Research Scientist.
(*d*) Theoretical, experimental and field investigation, applied research.
(*e*) Monitor the transport of radionuclides, liquid and vapor phase fluids, and associated waste materials within the unsaturated hydrologic domain. To accomplish this objective, available instrumentation and methods will be evaluated and optimal monitoring systems defined. This program will also develop new data collection and analysis systems applicable to transport monitoring.

011-10005-870-55

EVALUATION OF NUCLEAR POWER PLANT ENVIRONMENTAL IMPACT PREDICTION BASED ON MONITORING DATA

(*b*) Nuclear Regulatory Commission.
(*c*) L. D. Kannberg, Sr. Research Engineer.
(*d*) Field investigation, operation.
(*e*) Study has involved evaluation of the ecologic and thermal monitoring data for several power plant monitoring programs to determine what impacts were detected; what impacts were detectable; and what steps could be taken to improve monitoring programs. All of the plants considered had once-through or helper cooling systems. The monitoring results have been examined with respect to other monitoring programs and predicted impacts. The U.S. Nuclear Regulatory Commission supports this study to assess current monitoring programs, and define acceptable and unacceptable monitoring techniques.
(*g*) The evaluation has determined that the monitoring programs conducted were generally inadequate for detection of all but the larger, near discharge impacts. Recommendations were made for improvement of monitoring methodology.
(*h*) **Evaluation of Monticello Nuclear Power Plant Environmental Impact Prediction, Based on Monitoring Programs,** K. L. Gore, J. M. Thomas, L. D. Kannberg, D. G. Watson, *MNWL-2150*, 1976.
Evaluation of Haddam Neck (Connecticut Yankee) Nuclear Power Plant, Environmental Impact Prediction, Based on Monitoring Programs, K. L. Gore, J. M. Thomas, L. D. Kannberg, J. A. Mahaffey, D. G. Watson, *BNWL-2151*, 1976.
Evaluation of Millstone Nuclear Power Plant, Environmental Impact Prediction, Based on Monitoring Programs, K. L. Gore, J. M. Thomas, L. D. Kannberg, D. G. Watson, *BNWL-2152*, 1977.
Evaluation of Nuclear Power Plant Environmental Impact Prediction, Based on Monitoring Programs, Summary and Recommendations, K. L. Gore, J. M. Thomas, L. K. Kannberg, D. G. Watson, *BNWL-2153*, 1977.

011-10006-870-52

AN EXPERIMENTAL INVESTIGATION OF NEAR FIELD TEMPERATURES IN MECHANICAL DRAFT COOLING TOWER PLUMES

(*b*) Energy Research and Development Administration.

(*c*) L. D. Kannberg, Sr. Research Engineer.
(*d*) Experimental, applied research.
(*e*) Simulation of cooling tower plumes is being performed in a hydraulic flume at a length scale of 250:1 in order to investigate the effects of atmospheric and topographic conditions on plume dispersion and recirculation. The use of hydraulic flumes for this type of investigation is preferable to wind tunnels. Scaling advantages are gained by using water instead of air. The study will quantify the effects of various windspeeds, ambient stratification, tower operating conditions and local topographies on plume temperatures downwind of the tower and on recirculation to the tower for several towers in several siting configurations. The information will be used in the analysis of local and regional effects of multiple heat dissipation facilities at nuclear energy centers.
(*g*) Initial results for a single tower indicate that the thermal structure of the plumes strongly depends on local ambient flows.
(*h*) **Mathematical and Experimental Investigations on Dispersion and Recirculation of Plumes from Dry Cooling Towers at Wyodak Power Plant in Wyoming,** Y. Onishi, D. S. Trent, *BNWL-1982*, 1976.
Critical Review of Hydraulic Modeling on Atmospheric Heat Dissipation, Y. Onishi, S. M. Brown, *BNWL-2166*, 1977.

011-10007-870-73

DETERMINATION OF NEAR FIELD DILUTION OF COOLING SYSTEM EFFLUENTS FROM SOUTHERN CALIFORNIA EDISON COASTAL POWER PLANTS

(*b*) Southern California Edison Company.
(*c*) L. D. Kannberg, Sr. Research Engineer, Battelle-Northwest, or Harvey Chun, Engineer, Southern California Edison Company.
(*d*) Theoretical, applied research.
(*e*) Available computer codes are being modified and employed for examination of shallow, submerged, cooling system thermal discharges in Southern California coastal waters. Proposed mixing regulations require the determination of the initial mixing of effluents from municipal and industrial discharges. The study will provide data for determining the effects of such regulations on cooling system operation.

011-10008-870-52

HANFORD SITE GROUNDWATER MONITORING

(*b*) Energy Research and Development Administration.
(*c*) J. R. Raymond, Project Manager.
(*d*) Applied research, field investigation.
(*e*) Surveillance of groundwater on the Hanford site is one facet of a comprehensive Environmental Monitoring Program designed to evaluate existing and potential pathways of radiation exposure from project operations. Objectives of the Groundwater Monitoring Program are to measure and report the concentration and distribution of radioactive and chemical constituents in the groundwater, determine the movement and transport or contaminants with time, and determine the impact on the environs.
(*g*) Results from the Groundwater Monitoring Program continue to show no adverse offsite impact from Hanford operations.
(*h*) **Environmental Monitoring Report on Radiological Status of the Groundwater Beneath the Hanford Site, January-December 1974,** J. R. Raymond, et al., *BNWL-1970*, 1976.
Environmental Monitoring Report on the Status of Groundwater Beneath the Hanford Site, January-December 1975, D. A. Myers, et al., *BNWL-2034*, 1976.
Environmental Monitoring Report on the Status of Groundwater Beneath the Hanford Site, January-December 1976, D. A. Myers, et al., 1977 (in progress).

011-10009-820-75

DEVELOPMENT OF A MATHEMATICAL GROUNDWATER MODEL FOR CLARK COUNTY, WASHINGTON

(*b*) Arvid Grant and Associates, Consulting Engineers.
(*c*) C. R. Cole, Sr. Research Scientist.
(*d*) Applied research, numerical modeling of hydrologic systems.
(*e*) Develop a groundwater simulation model of the subject area to provide a tool for predictive assessment of water resource management policies.
(*f*) Completed.
(*g*) The Variable Thickness (VTT) Groundwater Flow Model was used to simulate the Clark County groundwater system.
(*h*) **Sponsor Completion Report,** C. R. Cole, R. W. Wallace, 1977.

011-10010-820-60

DEVELOPMENT OF A MATHEMATICAL GROUNDWATER MODEL OF THE AHTANUM-MOXEE SUB-BASINS, YAKIMA COUNTY, WASHINGTON

(*b*) Washington State Department of Ecology.
(*c*) J. R. Eliason, Manager, Resource Systems Section.
(*d*) Applied research, numerical modeling of hydrologic systems.
(*e*) Develop a groundwater simulation model of the subject area to provide a tool for predictive assessment of water resource management policies.
(*f*) Completed.
(*g*) A multiaquifer digital computer model which includes interaquifer transfer was developed for the groundwater system of the Moxee-Ahtanum sub-basins. It was initially planned to treat the groundwater system as an interconnected two-aquifer system. However, initial analysis of the data indicated that the problem would be better approached as two independent, interconnected three-aquifer systems with a common sink, the Yakima River. The model was adatped and calibrated on each of the systems using available data.
(*h*) **Mathematical Groundwater Model of the Ahtanum-Moxee Sub-Basins, Yakima County, Washington,** D. B. Cearlock, C. R. Cole, H. P. Foote, R. W. Wallace, 1975 (Sponsor report).

BROOKHAVEN NATIONAL LABORATORY, Department of Applied Science, Upton, N.Y. 11973.

012-10178-450-52

COASTAL TRANSPORT AND DIFFUSION

(*b*) ERDA.
(*c*) Thomas Hopkins, Oceanographic Science Division.
(*d*) Field research with theoretical background; basic research, partly applied and involves some development of research equipment.
(*e*) A field and theoretical study of circulation and diffusion in the coastal boundary layer (nearshore region) south of Long Island. Four instrumented buoys include sixteen electromagnetic current meters, sixteen conductivity sensors, and thirty-two thermistors. Data are continuously averaged *in situ* for hourly periods and telemetered to a coastal control station in real time.
(*g*) Eight months of data collection including testing and a current meter intercomparison provides some insight into the seasonal nature of nearshore shelf currents, and it has been hypothesized that a longshore pressure gradient produces a significant amount of the forcing of the well-known southwest drift of the currents in the Mid-Atlantic Bight.
(*h*) **A Compilation of Mixed Layer Current Meter and Wind Observations from the Wind Observations from the 1975 SMILE experiment,** F. Bruzoni, I. S. F. Jones, *WHOI Technical Report 76-110*, 1976.

Barotropic Currents Over the Continental Shelf, G. T. Csanady, *J. Phys. Oceanogr.* **4,** pp. 352-371, 1974.
Wind-Driven and Thermohaline Circulation Over the Continental Shelves, G. T. Csanady, *Proc. Conference on Effects of Energy-Related Activities on the Atlantic Continental Shelf,* ed. B. Manowitz, held at Brookhaven National Lab., Nov. 1975, *BNL 50484.*
Mean Circulation in Shallow Seas, G. T. Csanady, *J. Geophys. Res.* **81,** pp. 5389-5400, 1976.
The Coastal Boundary Layer, G. T. Csanady, *Proc. AAAS Symp. Estuaries,* Boston, Mass., Feb. 1976. Edited by C. Offices.
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The Coastal Jet Conceptual Model in the Dynamics of Shallow Seas, G. T. Csanady, *The Sea* **6,** ed. J. J. O'Brien, 1977 (in press). John Wiley & Sons.
Real-Time Acquisition of Oceanographic Data, D. G. Dimmler, *Proc. ERDA-Wide Conference on Computer Support of Environmental Science and Analysis,* Albuquerque, 9-11 July 1975.
A Controllable Real-Time Data Collection System for Coastal Oceanography, D. G. Dimmler, N. Greenlaw, S. Rankowitz, *Oceans '76,* Sept. 1976. (To be published in IEEE Journal).
The Scaling of Velocity Fluctuations in the Surface Mixed Layer, I. S. F. Jones, B. C. Kenney, *J. Geophys. Res.* **82** (in press), 1977.
Nearshore Currents Off Long Island, J. T. Scott, G. T. Csanady, *J. Geophys. Res.* **81,** pp. 5401-5409.

012-10179-660-55

THERMAL HYDRAULIC DEVELOPMENT PROGRAM FOR LIGHT WATER REACTOR SAFETY RESEARCH

(*b*) Office of Water Reactor Safety Research, U.S. Nuclear Regulatory Commission.
(*c*) Dr. O. C. Jones, Jr., Department of Applied Science.
(*d*) Experimental and theoretical investigation; applied research.
(*e*) Develop improved models, with experimental verification, of the non-equilibrium vaporization rates under conditions of interest regarding water reactor safety (e.g., flashing flow, post-dryout condition, subcooled boiling). The project is also directed towards developing improved local two-phase flow instruments and developing improved calibration methods for two-phase global instruments.
(*h*) **Evaporation in Variable Pressure Fields,** O. C. Jones, Jr., N. Zuber, *Paper No. 76-CSME/CSChE-12.* Presented 16th Natl. Heat Transfer Conf., St. Louis, Aug. 1976.
Liquid Deficient Cooling in Dispersed Flows: A Non-Equilibrium Relaxation Model, O. C. Jones, Jr., N. Zuber. Accepted *17th National Heat Transfer Conf.,* Salt Lake City, Aug. 1977.
BNL Light Water Reactor Thermohydraulic Development Program: Instrumentation Tasks, O. C. Jones, Jr., *BNL-NUREG-22588,* Mar. 1977.
Reactor Safety Research Programs (Quarterly Progress Rept., Oct. 1-Dec. 31, 1976), *BNL-NUREG-50624,* pp. 246-280, Feb. 1977.

012-10180-660-55

THERMOHYDRAULIC LIQUID METAL FAST BREEDER REACTOR SAFETY EXPERIMENTS

(*b*) Nuclear Regulatory Commission, Division of Reactor Safety Research.
(*c*) Dr. Owen C. Jones, Jr., Department of Applied Science.
(*d*) Applied and basic, experimental (laboratory) and analytical research.
(*e*) Experimental and analytical research is conducted on thermalhydraulic phenomena important in safety analyses of fast breeder reactors. The fluid dynamic and heat transfer characteristics of volume-heated boiling pools are studied. Steady state and transient two-phase, single- and multi-component void dynamics, flow regime transitions and heat · transfer to system boundaries are investigated. Transient flow and solidification of single- and two-phase liquid/vapor molten systems are studied. The effects on non-condensable gases on heat and mass transfer processes are investigated. Laboratory experiments in the areas described are carried out in simulant environments. Analytical work is directed towards predictive models and derivation of scaling parameters.
(*h*) **Heat Transfer from a Volume Heated Boiling Pool,** J. C. Chen, W. R. Gustavson, M. S. Kazimi. Presented *PAHR Information Exchange Mtg.,* Sandia Laboratories, Albuquerque, Nov. 13-14, 1975.
Post-Accident Downward Relocation of Molten Fuel, M. S. Kazimi, R. D. Gasser. Presented *PAHR Information Exchange Mtg.,* Sandia Laboratories, Albuquerque, Nov. 13-14, 1975.
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Heat Transfer from Boiling Heat-Generating Pools, J. C. Chen, W. R. Gustavson, M. S. Kazimi, *Trans. Amer. Nucl. Soc.* **23,** 367, June 1976.
On the Downward Propagation of a Molten Heat-Generating Pool, M. S. Kazimi, J. C. Chen, *Trans. Amer. Nucl. Soc.* **23,** 362, June 1976.
Thermohydraulic LMFBR Safety Experiments; Quarterly Progress Rept., Jan.-Mar. 1976, M. S. Kazimi, *BNL-NUREG 50526,* July 1976.
Heat Transfer and Fluid Dynamic Characteristics of Internally Heated Boiling Pools, W. R. Gustavson, J. C. Chen, M. S. Kazimi, *BNL-NUREG-21856,* Sept. 1976.
Solidification Dynamics of Flowing Fluids–Preliminary Data Evaluation, M. H. Chun, M. S. Kazimi, T. Ginsberg, O. C. Jones, Jr., *BNL-NUREG-22068,* Nov. 1976.
Role of Condensation on Dispersion of Closed Boiling UO_2 Systems, T. Ginsberg, *Trans. Amer. Nucl. Soc.,* N.Y., June 1977.

CALIFORNIA INSTITUTE OF TECHNOLOGY, Department of Chemical Engineering, Pasadena, Calif. 91125. Dr. John H. Seinfeld, Professor and Executive Officer.

013-08702-120-54

THE MOTION OF BUBBLES, DROPS AND RIGID PARTICLES IN NEWTONIAN AND NON-NEWTONIAN FLUIDS

(*b*) Sponsored in part by the National Science Foundation.
(*c*) Professor L. G. Leal.
(*d*) Experimental and theoretical; basic research; M.S. and Ph.D. theses.
(*e*) Experimental and theoretical studies aimed at improved understanding of the motion of bubbles, drops or small particles in the slow flow regime for both Newtonian and non-Newtonian (primarily polymeric solutions) fluids.
(*h*) **The Slow Motion of Slender Rod-Like Particles in a Second Order Fluid,** L. G. Leal, *J. Fluid Mech.* **69,** 305 (1975).
Dissolution of a Stationary Gas Bubble in a Viscoelastic Fluid, E. Zana, L. G. Leal, *I&EC Fundamentals* **14,** 175 (1975).
The Creeping Motion of Liquid Drops Through a Circular Tube of Comparable Diameter, B. P. Ho, L. G. Leal, *J. Fluid Mech.* **71,** 361 (1975).
Migration of Rigid Spheres in a Two-Dimensional Unidirectional Shear Flow of a Second-Order Fluid, B. P. Ho, L. G. Leal, *J. Fluid Mech.* **76,** 783 (1976).
A Note on the Creeping Motion of a Viscoelastic Fluid Past a Sphere, E. Zana, G. Tiefenbruck, L. G. Leal, *Rheologica Acta* **14,** 891 (1975).
The Dynamics and Dissolution of Gas Bubbles in a Viscoelastic Fluid, E. Zana, L. G. Leal, to appear *Intl. J. Multiphase Flow.*

Sedimentation of Slender Rod-Like Particles in the Vicinity of a Plane Boundary, W. B. Russell, E. J. Hinch, G. Tiefenbruck, L. G. Leal, to appear *J. Fluid Mech.*
A Note on the Motion of a Spherical Particle in a General Quadratic Flow of a Second-Order Fluid, P. C. H. Chan, L. G. Leal, to appear *J. Fluid Mech.*

013-08703-120-54

SUSPENSION MECHANICS AND RHEOLOGY

(*b*) Sponsored, in part, by the National Science Foundation, Petroleum Research Fund, Research Corporation, Union Carbide Corporation.
(*c*) Professor L. G. Leal.
(*d*) Primarily theoretical; basic research; Ph.D. theses.
(*e*) Theoretical studies aimed at predicting the rheological and bulk transport properties of suspensions.
(*h*) **Constitutive Equations in Suspension Mechanics, Part I. General Formulation,** E. J. Hinch, L. G. Leal, *J. Fluid Mech.* **71,** 481 (1975).
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The Effective Thermal Conductivity of a Dilute Suspension of Rigid Spheroids in Simple Shear Flow, T. J. McMillen, L. G. Leal, *CIT Report.*
Macroscopic Transport Properties of a Sheared Suspension, L. G. Leal, to appear in *J. Colloid and Interface Sci.;* also reprinted in *Colloid and Interface Science* **1,** *Plenary and Invited Lectures,* ed. Kerker, Zettlemoyer and Powell, Academic Press (1977).
Approximate Constitutive Forms in Suspension Mechanics, L. G. Leal, *Proc. VII Intl. Congress of Rheology,* p. 392 (1976).

013-08704-060-54

GEÒPHYSICAL FLUID DYNAMICS ; BUOYANCY DRIVEN FLOWS, TURBULENT MODEL DEVELOPMENT

(*b*) Sponsored, in part, by the National Science Foundation.
(*c*) Professor L. G. Leal.
(*d*) Theoretical; basic research; Ph.D. theses.
(*e*) Theoretical studies aimed at problems which involve both ambient stratification and "local" buoyancy induced convection. Theory for mean gravitational circulation in shallow bodies of water. Development of a computationally useful model for calculation of turbulent motions with stratification in mescoscale (or smaller) regions.
(*h*) **The Role of Upper Surface Conditions in Establishing the Flow Structure for Natural Convection in a Shallow Cavity with Differentially Heated End Walls,** G. P. Stone, D. E. Cormack, ·L. G. Leal, *J. Heat/Mass Transfer* **18,** 635 (1975).
Wakes in Stratified Flow Past a Hot or Cold Two-Dimensional Body, G. E. Robertson, J. H. Seinfeld, L. G. Leal, *J. Fluid Mech.* **75,** 233 (1975).
An Evaluation of Mean Reynolds Stress Turbulence Models: The Triple Velocity Correlation, D. E. Cormack, J. H. Seinfeld, L. G. Leal, to appear *J. Fluid Engrg.*

013-09946-190-00

MODEL STUDIES OF SURFACTANT TRANSPORT AND THEOLOGY AT A FLUID INTERFACE

(*c*) Professor L. G. Leal.
(*d*) Primarily theoretical; basic research; Ph.D. theses.
(*e*) Micromechanical studies of surfactant species at a fluid interface, including both transport and surface rheology effects.
(*h*) **A Model for Surface Diffusion on Solids,** H. Brenner, L. G. Leal, to appear in *J. Colloid and Interface Sci.*
A Micromechanical Derivation of Fick's Law for Interfacial Diffusion of Surfactant Molecules, H. Brenner, L. G. Leal, submitted to *J. Colloid and Interface Sci.*
A Dynamical Derivation of Gibb's Equation for Interfaces, H. Brenner, L. G. Leal, submitted to *J. Colloid and Interface Sci.*
Interfacial Resistance to Interphase Mass Transfer in Quiescent Two-Phase Systems, H. Brenner, L. G. Leal, submitted to *AIChE Journal.*

CALIFORNIA INSTITUTE OF TECHNOLOGY, Division of Engineering and Applied Science, Engineering Science Department, Pasadena, Calif. 91125. Dr. Robert H. Cannon, Jr., Division Chairman.

014-01548-230-20

PROBLEMS IN HYDRODYNAMICS

(*b*) National Science Foundation.
(*c*) Professor Milton S. Plesset.
(*d*) Theoretical and experimental; basic research.
(*e*) Studies of cavitating and noncavitating flow; dynamic behavior of cavitation bubbles; theoretical studies of cavitation damage, boiling heat transfer.
(*h*) **Nonlinear Oscillations of a Gas Bubble in a Viscous Incompressible Liquid,** M. S. Plesset, A. Prosperetti, *Rept. No. 85-61, May 1973.*
Nonlinear Oscillations of Gas Bubbles in Liquids. Transient Solutions and the Connection Between Cavitation and Subharmonic Emission, A. Prosperetti, *J. Acous. Soc. of Amer.,* Jan. 1976.
Vapor Bubble Dynamics and Heat Transfer in Nucleate Boiling, A. Prosperetti, *Symp. Intl. Assoc. Hydraulic Research,* Grenoble, France, Mar. 30-Apr. 2, 1976 (submitted to Intl. J. Heat & Mass Transfer).
Flow of Vapour in a Liquid Enclosure, A. Prosperetti, *J. Fluid Mech.* **78,** 3, pp. 433-444, 1976.
Bubble Dynamics and Cavitation, A. Prosperetti, *Ann. Rev. Fluid Mech.* **9,** pp. 145-185, 1977.

CALIFORNIA INSTITUTE OF TECHNOLOGY, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, Calif. 91103. Dr. B. H. Murray, Laboratory Director.

015-09785-550-50

ADVANCED PROPELLANT PERFORMANCE MODELING

(*b*) NASA/OAST (RP).
(*c*) Dr. Raymond Kushida, Energy and Materials Research Section.
(*d*) Experimental and theoretical applied research.
(*e*) Studies of the mixing and reaction occurring in impinging jets of liquids and gases are being conducted with the purpose of providing design criteria for liquid rocket injectors. Analytic models of three-dimensional impinging jet flow fields have been developed.

CALIFORNIA STATE UNIVERSITY, FULLERTON, Division of Engineering, Fullerton, Calif. 92634. Richard R. Brock, Chairman, Civil Engineering/Engineering Mechanics Faculty.

016-07978-820-33

HYDRODYNAMICS OF ARTIFICIAL GROUNDWATER RECHARGE

(*d*) Theoretical research.
(*e*) A continuing study to develop reliable methods for predicting the hydrodynamic behavior of recharge mounds below recharge ponds with emphasis on mound shape.
(*g*) The case where a perched mound develops on a horizontal semi-previous layer has been investigated using the DF theory. The potential theory is being used in order to establish the range of validity of the results from the DF theory.
(*h*) **Dupuit-Forchheimer and Potential Theories for Recharge From Basins,** R. R. Brock, *Water Resources Research* **12,** 5, pp. 909-911, Oct. 1976.
Hydrodynamics of Perched Mounds, R. R. Brock, *J. of Hydraulics Div., ASCE* **102,** HY8, pp. 1083-1100, Aug. 1976.

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CALIFORNIA STATE UNIVERSITY, LOS ANGELES, Department of Civil Engineering, 5151 State University Drive, Los Angeles, Calif. 90032. Dr. Young C. Kim, Professor and Chairman.

017-10024-870-54

OIL SLICK TRANSPORT ON SHOALING WATERS

(*b*) National Science Foundation Institutional Grant.
(*d*) Experimental and theoretical; applied research.
(*e*) The area of oil spread was measured in the laboratory and the predictable model was established in determining the spreading area of oil on coastal waters. The relationship between the oil slick and the Reynolds, Froude, and Weber numbers was examined and the influence of wind, currents, and waves on the spread area was investigated. The effects on the changes in water depth and the alteration of the net spreading coefficient on oil spreading capacity were also examined. Comparison between the existing field measurements and the laboratory work was made.
(*g*) There is a need for more scientifically controlled investigation on oil slick transport, particularly in the determination of true wind, waves, and current velocities. Further research is needed in developing more realistic solutions to the three-dimensional oil spreadinphenomena.
(*h*) **Oil Spreading on Coastal Waters,** Y. C. Kim, *Proc. 14th Intl. Conf. on Coastal Engrg.*, Copenhagen, June 1974.

017-10025-430-54

WAVE ENERGY ABSORBTION IN COASTAL STRUCTURES

(*b*) National Science Foundation.
(*d*) Experimental and theoretical; applied research.
(*e*) Model tests on perforated breakwater systems were carried out to evaluate the reflection coefficients and the reduction of incident wave pressures. The effect of perforating the bottom wall was studied to determine the extent of further reduction of pressure on the breakwater.
(*h*) **A Slit-Type Breakwater,** S. Nagai, S. Kakuno, *Proc. 15th Intl. Conf. Coastal Engrg.*, Hawaii, June 1976.

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CALIFORNIA STATE UNIVERSITY, SACRAMENTO, Department of Civil Engineering, 6000 J Street, Sacramento, Calif. 95819. Ajit S. Virdee, Department Chairman.

018-09786-220-60

ANALYSIS OF TRACTIVE FORCES TO MINIMIZE DITCH EROSION

(*b*) California Department of Transportation.
(*c*) Richard Howell, Environmental Improvement Section, Dept. of Transportation, 5900 Folsom Boulevard, Sacramento, Calif. 95819, or Dr. Alan Prasuhn, Department of Civil Engineering, California State University, Sacramento, Calif. 95819.
(*d*) Experimental and field investigation; applied research for Master's thesis.
(*e*) Development of analytical techniques for design engineers to predict the extent and magnitude of ditch erosion along highway drainage ditches. Results verified in the field.
(*f*) Completed.
(*g*) Allows design engineers to provide scour protection where necessary.

018-09787-820-36

GROUNDWATER MONITORING: DEVELOPMENT OF A METHODOLOGY AND A SAMPLE APPLICATION

(*b*) U.S. Environmental Protection Agency.
(*c*) William Marshall, State Water Resources Control Board, P.O. Box 100, Sacramento, Calif. 95801, or Dr. Kenneth D. Kerri, Department of Civil Engineering, California State University, Sacramento, Calif. 95819.
(*d*) Field investigation; applied research for Master's thesis.
(*e*) Development of analytical techniques (including economic factors) to determine and prioritize locations of groundwater sampling stations.
(*f*) Completed.
(*g*) Provides a method for determining locations of groundwater sampling stations.

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UNIVERSITY OF CALIFORNIA, BERKELEY, College of Engineering, Department of Civil Engineering, Division of Hydraulic and Sanitary Engineering, Berkeley, Calif. 94720. Professor J. W. Johnson.

019-06224-420-11

TSUNAMIS

(*b*) U.S. Army Coastal Engrg. Res. Center.
(*c*) Professor R. L. Wiegel.
(*d*) Experimental and theoretical; basic research.
(*e*) Model and theoretical studies of water waves generated by horizontal fault moving normal to a channel or escarpment, and generated by a rockfall into a reservoir.
(*f*) Completed.
(*g*) See (e).
(*h*) **3-D Hydraulic Model of Waves Generated by Displacements,** Shin-Lin Liu, R. L. Wiegel, *Proc. 15th Intl. Conf. Coastal Engrg.*, 11-17 July 1976, Honolulu, Hawaii, ASCE, Ch. 63 (in press).

019-07151-870-61

WASTE DISPOSAL SYSTEMS

(*b*) Water Resources Center.
(*c*) Professor R. L. Wiegel.
(*d*) Experimental, basic and applied research.
(*e*) Perform model studies of the mixing processes associated with sewage effluent being discharged on ocean bottom and buoyant power plant cooling water being discharged at ocean surface.
(*f*) Completed.
(*g*) Model studies of the effects of wind-generated waves on the mixing of buoyant jets are being made.
(*h*) **Wastewater Disposal by Submerged Manifolds,** P. Liseth, *J. Hydraul. Div., Proc. ASCE* **102,** HY1, pp. 1-14, Jan. 1976.
Mixing of Submerged Two-Dimensional Buoyant Jets in Uniform Bodies of Water in the Absence and Presence of Wind Action, Shin-Lin Liu, *Ph.D. Thesis*, Dept. of Civil Engrg. (also, *Univ. Calif. Hyd. Engrg. Lab. Rept. HEL 23-5*), 142 pages, June 1976.

019-08046-870-61

THE MECHANICS OF HEAT DISPOSAL IN STREAMS AND ESTUARIES

(*b*) Water Resources Center, Univ. of California; National Science Foundation.
(*c*) Hugo B. Fischer, Professor.
(*d*) Experimental; basic research.
(*e*) Experiments were conducted in a new tidal flume 1,000 ft long and 12 ft wide. The effects of various geometries on longitudinal and transverse dispersion in partially mixed estuaries were investigated. The stability of the energy budget calculation for predicting water temperatures was also examined.
(*f*) Completed.
(*h*) **Transverse Dispersion in Partially Stratified Tidal Flow,** S. M. Sumer, *Ph.D. Thesis*, Dept. of Civil Engrg.; also, *Waste Heat Management Rept. 20*, Hyd. Engrg. Lab., Univ. of Calif., 218 pages, May 1976.
An Energy Budget Formulation for Temperature Prediction in Vertically Mixed Water Bodies, R. Spigel, *Waste Heat Management Rept. 22*, Hyd. Engrg. Lab., Univ. of Calif., 65 pages, Mar. 1977.

019-08781-520-60

STUDY OF TOMALES "SNEAKER WAVE"

(*b*) California State Divsion of Navigation and Ocean Development, and University of California Sea Grant.
(*c*) Hugo B. Fischer, Professor.
(*d*) Experimental and field investigation.
(*e*) Possible causes of frequent boating accidents at the mouth of Tomales Bay, which are frequently ascribed to a mysterious "sneaker wave" were investigated.
(*f*) Completed.
(*h*) **An Investigation of Possible Causes of the So-Called "Sneaker Wave" at Tomales Bay, California,** H. B. Fischer, R. H. French, R. Della, *Univ. Calif. Hyd. Engrg. Lab. Rept. HEL 28-1*, 37 pages, 1976.

019-08782-420-11

EFFECT OF LARGE NEARSHORE STRUCTURES ON WAVE MOTION IN THE VICINITY OF THE STRUCTURE AND ADJACENT COAST

(*b*) Corps of Engineers, U.S. Army, Coastal Engineering Research Center.
(*c*) Professor R. L. Wiegel.
(*d*) Experimental and theoretical; basic research.
(*e*) Studies were made of the characteristics of waves diffracted by offshore structures such as a man-made island, both near to and far from the structures.
(*f*) Completed.
(*h*) **Diffraction of Water Waves by Cylindrical Structures of Arbitary Shape,** V. W. Harms, *Ph.D. Thesis*, Dept. of Civil Engrg. (also, *Univ. Calif. Hyd. Engrg. Lab. Rept. HEL 1-23*), 339 pages, Dec. 1975.

019-08783-420-11

WAVE FORCES ON PIPELINES AT OR NEAR THE BOTTOM

(*b*) Corps of Engineers, U.S. Army, Coastal Engineering Research Center.
(*c*) Professor R. L. Wiegel.
(*d*) Experimental and theoretical; basic research.
(*e*) Studies have been made of the forces exerted by waves on a pipeline at or near the bottom. A new equation was developed to describe the relationship between the measured force and the basic parameters. Coefficients in the equation were determined empirically.
(*f*) Completed.
(*h*) **Forces Exerted by Waves on a Pipeline at or Near the Ocean Bottom,** G. L. Bowie, *Ph.D. Thesis*, Dept. of Civil Engrg., 213 pages, June 1977.

019-08784-870-73

HYDRAULIC MODEL STUDY OF THE COOLING WATER SYSTEM PROPOSED FOR DIABLO CANYON FOR THE PURPOSE OF DETERMINING THE VALIDITY OF SUCH A MODEL TO PREDICT THE PROTOTYPE FOR VARIOUS OCEANIC CONDITIONS

(*b*) Pacific Gas and Electric Company.
(*c*) Professor R. L. Wiegel.
(*d*) Experimental.
(*e*) An undistorted 1:75 scale model of a 1,100 megawatt power plant has been designed, constructed and used to study the mixing characteristics of the system, based upon densimetric Froude modeling. Also, a separate study is being made in a different facility on the effect of the mixing and trajectory of the plume, of winds blowing over the water surface.
(*g*) Model studies are being made.
(*h*) **Report on Model Study of Cooling Water System of Pacific Gas and Electric Company Nuclear Power Plant Located at Diablo Canyon, California,** R. L. Wiegel, V. W. Harms, B. Safaie, J. D. Cumming, R. P. Della, C. B. Leidersdorf, C. Young, *Tech. Rept. No. HEL 27-2*, pp. 113, Jan. 1976. Also published as *Supplement No. 8* to the Diablo Canyon Environmental Rept. (Docket Nos. 50-275-OI and 50-323-OL), Feb. 4, 1976, to the U.S. Nuclear Regulatory Commission.

019-10122-220-10

TEMPERATURE EFFECTS ON SEDIMENT TRANSPORT AND RIVER BEDFORMS

(*b*) U.S. Corps of Engineers.
(*c*) Professor J. A. Harder.
(*d*) Experimental, applied research.
(*e*) Determine the effect of water temperature on sediment transport rates and bedforms in the Missouri River near Omaha.
(*f*) Completed.
(*g*) It has been found that the river behavior can be explained with the aid of laboratory flume studies and theory, and that the temperature effect does not necessarily depend on sediment suspension.

019-10123-430-44

EARTHQUAKE LOADING ON LARGE OFFSHORE STRUCTURES IN DEEP WATER–A STUDY OF THE CORRELATION OF ANALYTIC AND PHYSICAL MODELS

(*b*) Sea Grant, NOAA and the State of California.
(*c*) Professor R. L. Wiegel.
(*d*) Experimental and theoretical; basic research.
(*e*) To provide information with which rational designs can be made of such structures as offshore oil storage tanks for high earthquake-risk areas. Physical tests will be made on the 20 ft by 20 ft earthquake simulator ("shaking table"), which will be "immersed" in a large water tank. A numerical model will be developed and compared with physical measurements.

019-10124-860-61

THE INFLUENCE OF RIVER WATER QUALITY ON STORAGE RESERVOIR MANAGEMENT

(*b*) Water Resources Center, Univ. of California.
(*c*) Professors J. Imberger and H. B. Fischer.
(*d*) Experimental and theoretical; basic research.
(*e*) To demonstrate the usefulness of an exact description of the water motions when constructing a water quality model of a reservoir. The work proposed will validate and extend the recent model of Imberger, et al. (1976), and couple this with a water quality model. The more accurate description of the water motions and vertical and horizontal mixing is expected to yield consistently better water quality predictions.

019-10125-400-54

DEVELOPMENT AND FULL-SCALE TESTING OF NUMERICAL PROGRAMS FOR ESTUARINE POLLUTION STUDIES

(*b*) National Science Foundation.
(*c*) Professor Hugo B. Fischer.
(*d*) Theoretical and field investigation.
(*e*) A number of two-dimensional programs are being used to predict the hydrodynamics and transport of pollutants in estuaries, and efforts are being made to develop three-dimensional versions. The purpose of this project is to obtain detailed full-scale data in a typical coastal embayment of the type not previously studied and to use the data to analyse the capabilities of present and proposed numerical programs.

019-10126-840-31

CONTROL OF IRRIGATION SYSTEMS USING WATER LEVEL SENSORS AND REAL-TIME COMPUTER SIMULATION

(*b*) U.S. Bureau of Reclamation, Denver.
(*c*) Professor J. A. Harder.
(*d*) Theoretical, field experimental.
(*e*) To establish the optimal means of automatically controlling irrigation check gate positions according to arbitrary water demands.

CALIFORNIA, UNIVERSITY OF AT BERKELEY, Lawrence Berkeley Laboratory (see Lawrence Berkeley Laboratory listing).

UNIVERSITY OF CALIFORNIA, DAVIS, Department of Land, Air and Water Resources, Water Science and Engineering Section, Davis, Calif. 95616. Robert H. Burgy, Section Vice Chairperson.

020-07926-420-00

WAVE DEFORMATION IN WATER OF NONUNIFORM DEPTH

(*c*) Dr. Theodor Strelkoff.
(*d*) Theoretical/basic; Ph.D. thesis.
(*e*) Conformal mapping and complex-variable theory is used to solve two-dimensional unsteady irrotational flows of water with a free surface deforming under the influences of gravity.
(*f*) Completed.
(*g*) Unsteady motion of water in a solitary wave was predicted. Comparison with the results of steady-flow analysis utilizing a coordinate system moving with constant velocity show agreement.
(*h*) **The Numerical Solution of Surface Waves by Conformal Mapping,** M. Dehghani. Dissertation in partial fulfillment of the requirements for Ph.D. Degree, Univ. of Calif., Davis, 43 pages, Sept. 1973.

020-07927-840-05

COMPUTER MODELS FOR DETERMINING IRRIGATION EFFICIENCIES

(*b*) Agricultural Research Service, U.S. Department of Agriculture.
(*c*) Dr. Theodor Strelkoff.
(*d*) Theoretical/applied; design, operation; M.S. thesis.
(*e*) Mathematical models of the surface-irrigation process are constructed by numerically solving the governing partial-differential equation of flow over a porous bed for given design parameters; ground roughness and infiltration characteristics, vegetative density, length and slope of field; also given management option; size of stream, duration, and variation with time. The resulting degree of uniformity of subsurface distribution of water, the wastage in runoff from the end of the field and in deep percolation, and the efficiency of water application are thus determined.
(*g*) Solution of the diffusing (zero-inertia) equations of motion yields results equivalent in practical cases to solution by the complete Saint-Venant equations. Normal-depth (kinematic-wave) models are adequate only in sufficiently steep fields.
(*h*) **Hydrodynamics of Surface Irrigation-Advance Phase,** J. G. Sakkas, T. Strelkoff, *J. Irrigation and Drainage Div., Proc. ASCE* **100(IR1)**, pp. 31-48, Paper 10422, Mar. 1974.
Discussion of: Flow Resistance from Cylindrical Roughness, T. Strelkoff, D. D. Fangmeier, *J. Irrigation and Drainage Div., Proc. ASCE* **100(IR3)**, pp. 390-393, Paper 10771, Sept. 1974.
Shallow Water Equations at Low Froude Numbers, N. D. Katopodes. Thesis submitted in partial satisfaction of the requirements for M.S. Degree, Univ. of California, Davis, pp. 1-51, Dec. 1974.

020-10076-310-54

FLOODING FROM RUPTURED DAMS

(*b*) National Science Foundation.
(*c*) Dr. Theodor Strelkoff.
(*d*) Theoretical; basic and applied; Ph.D. thesis.
(*e*) The movement of water out of a reservoir following partial or total collapse of a dam is viewed from the standpoint of shallow-water theory in one space dimension (flow confined by valley walls) and two space dimensions (unconfined flow, possible cross slope). In one-dimension, results of two models based on the Saint-Venant equations (second-order method of characteristics applied to constant time lines and a two-step predictor-corrector scheme [Vasiliev] employing the momentum-conservation form of the equation of motion) are compared to results of a diffusing (zero-inertia) form of the equations, a normal-depth kinematic-wave model, and physical experiments performed in model valleys of simple geometry, by the U.S. Corps of Engineers. The aim is prediction of maximum stages and wave-arrival times at points downstream from the affected dam. In two space dimensions, the method of characteristics is extended to the generation of characteristic conoid surfaces, the apices of which all touch a sequence of constant-time planes to advance the solution through time.
(*g*) Models based on the Saint-Venant equations adequately describe flow resulting from dam failure. The normal-depth model is useful only for smooth, steep channels or small breaches.
(*h*) **The Dam-Break Problem in a Prismatic Dry Channel,** J. G. Sakkas, T. Strelkoff, *J. Hydraulics Div., Proc. ASCE* **99**, HY12, pp. 2195-2216, Paper 10233, Dec. 1973.
Dimensionless Solution of Dam-Break Flood Waves, J. G. Sakkas, T. Strelkoff, *J. Hydraulics Div., Proc. ASCE* **102**, HY2, pp. 171-184, Paper 11910, Feb. 1976.

020-10077-700-00

POTENTIAL FLOW OVER LOW SHARP-CRESTED WEIRS

(*c*) Dr. Theodor Strelkoff.
(*d*) Theoretical, basic; M.S. thesis.
(*e*) Conformal mapping and complex-variable theory is used in an iterative numerical scheme for determining flow profiles and discharge coefficients over vertical sharp-crested weirs with a head h to height w ratio $5 < h/w < 11$.
(*f*) Completed.
(*g*) For $h/w < 11.071$, the Froude number of the approaching flow is less than unity. Critical flow upstream from the weir is established at nonzero weir height, specifically, at $h/w = 11.071$.
(*h*) **Potential Flow Over a Vertical Sharp-Crested Weir,** D. R. Schamber. Thesis submitted in partial satisfaction of the requirements for M.S. Degree, Univ. of Calif., Davis, pp. 1-75, June 1976.

020-10078-820-54

MECHANISM OF FROST HEAVING IN EMBANKMENTS

(*b*) National Science Foundation.
(*c*) J. N. Luthin and G. S. Taylor.
(*d*) Experimental and computer model; basic research.

(*e*) Experiments will be conducted on the freezing of soil. Heat and moisture transfer will be measured. Soil characteristics will be determined. The experimental data will be used to verify a computer model of the process. The model will then be used to analyze the engineering design of embankments.
(*g*) Computer model has been developed using a finite difference scheme.

020-10079-200-60

EFFECTS OF WIND ON OPEN CHANNEL FLOWS

(*b*) California Department of Water Resources.
(*c*) Dr. J. Amorocho.
(*d*) Experimental; basic and applied; Ph.D. thesis.
(*e*) Determine relationships for prediction of wind setup and wind waves as functions of wind speed and fetch for canals and other open channels. Investigate means for wave suppression and proper operation of canals under conditions of high winds.
(*h*) **Some Factors Affecting Control of Flow in a Large Canal System,** J. J. DeVries, J. Amorocho, *Proc. Irrigation and Drainage Specialty Conf., ASCE*, pp. 329-352, Apr. 1973.
Wave Suppressors for the California Aqueduct, J. J. DeVries, J. Amorocho, *Water Sci. and Engrg.*, Paper No. 1054, Mar. 1974.

020-10080-350-60

FISH PROTECTIVE SYSTEMS FOR WATER INTAKES

(*b*) California Department of Water Resources.
(*c*) Dr. J. Amorocho.
(*d*) Experimental; applied research.
(*e*) Large diversions of water from rivers, lakes, and oceans for water supply, irrigation, and powerplant cooling can cause grave ecological problems due to the loss of fish and fish eggs and larvae. Development of practical schemes for protecting marine life at water intakes is being done by hydraulic model studies of intake structures and the development of a pilot installation in which tests are made with fish and with fish eggs and larvae.
(*h*) **Sand Filters for Screening at Water Diversions, a Feasibility Study,** J. J. DeVries, R. B. Krone, J. Amorocho, *Water Science and Engrg.*, Paper No. 1053, 48 pages, Nov. 1973.
Hydraulic Model Investigation of the Intake Structures for San Onofre Nuclear Generating Station Units 2 and 3, K. Thompson, J. J. DeVries, J. Amorocho, *Water Science and Engrg.*, Paper No. 1055, 81 pages, Apr. 1974.
Fish Swimming Ability and Impingment Test Chamber, W. Kreamer, J. DeVries, K. Thompson, *Water Science and Engrg.*, Paper No. 1056, 26 pages, Nov. 1974.
Fish Barrier Test Flume, J. DeVries, K. Thompson, W. Kreamer, *Water Science and Engrg.*, Paper No. 1060, 56 pages, Aug. 1975.

020-10081-170-31

USE OF RETARDANTS FOR CONTROL OF EVAPORATION IN SNOW FIELDS

(*b*) United States Bureau of Reclamation.
(*c*) Dr. J. Amorocho.
(*d*) Experimental: basic and applied.
(*e*) Develop methods for augmenting the yield of watersheds where the major precipitation is snow. A snow-melt lysimeter is being used to measure differences in amounts of melt water occurring from treated and untreated snow packs in a natural environment. Melt rates, snow density profiles, snow pack temperatures, and atmospheric conditions are being monitored through several complete snow seasons.
(*h*) **Snowmelt Lysimeter,** K. Thompson, J. DeVries, J. Amorocho, *Proc. Western Snow Conf.*, pp. 35-40, Apr. 1975.

UNIVERSITY OF CALIFORNIA, DAVIS, Division of Environmental Studies, Institute of Ecology, Davis, Calif. 95616. Professor G. A. Wandesforde-Smith, Acting Director.

021-09788-440-54

TURBULENCE STUDIES IN THE MIXED LAYER AND THERMOCLINE OF LAKE TAHOE

(*b*) National Science Foundation.
(*c*) Professor Thomas M. Powell.
(*d*) Field investigation, basic research.
(*e*) Experiments by a team of researchers from the Univesity of California, Davis, and Oregon State University were carried out in Lake Tahoe, California-Nevada, during September, 1976. Data taken include currents in the mixed layer, internal waves in the thermocline, and vertical temperature microstructure profiles. In addition, some measurements were made with a hot film sensor and a fixed microstructure probe (for horizontal microstructure surveys). We are investigating the character of the velocity variations in this lake, especially the character of the velocity fluctuation spectrum over a wide spectral range. In addition, we are calculating the modal structure, various spectra, cross spectra, and coherences from the internal wave data taken in the seasonal thermocline, comparing these with present theory and past experiments. The joint studies of microstructure with current and internal wave data will clarify the role that small scale temperature variations play in the dissipation of heat (and momentum) and the vertical transport of thermal energy. We hope to see the effects of current shears and internal wave activity upon the generation and dissipation of temperature microstructure.
(*g*) Calculation of low frequency spectra; calculation of vertical eddy diffusivities in the thermocline from vertical thermal microstructure data; description of the strong microstructure regions near a lake slope.
(*h*) **Low Frequency Trubulence Spectra in the Mixed Layer of Lake Tahoe, California-Nevada,** T. M. Dillon, T. M. Powell, *J. Geophys. Res.* **81**, 36, pp. 6421-6427, 1976.
Low Frequency Turbulence and Vertical Temperature Microstructure in Lake Tahoe, California-Nevada, T. M. Dillon, T. M. Powell, L. O. Myrup, *Verh. Internat. Verein. Limnol.* **19**, pp. 110-115, 1975.

UNIVERSITY OF CALIFORNIA, DAVIS, Department of Mechanical Engineering, Davis, Calif. 95616. Professor Allan A. McKillop, Department Chairman.

022-10057-220-50

TRAJECTORY ANALYSIS OF SALTATING PARTICLES

(*b*) NASA-Ames Research Center.
(*c*) Professor Bruce R. White.
(*d*) Experimental and theoretical, basic research, M.S. and Ph.D. theses.
(*e*) A sufficiently strong wind blowing over a sandy surface will pick up sand grains and cause them to skip along the surface in a series of short, flat trajectories. At each impact these bouncing grains may eject other grains, which in turn will begin to hop across the surface. The net result will be a flow of sand in the direction of the wind. This phenomenon is known as saltation. Saltation is of interest from a geologic point of view because it is the mechanism primarily responsible for the unique topography of sandy desert regions. The purpose of the present investigation was to learn more about the trajectories of saltating grains through the study and evaluation of high speed motion picture films to be taken in an atmospheric wind tunnel.
(*g*) High speed motion pictures (2000 frames/second) of saltating spherical glass microbeads (350-710 micron diameter range and 2.5 gm/cc density) were taken in an environmental wind tunnel to simulate the planetary boundary layer. Analysis of the experimental particle trajectories show the presence of a substantial lifting force in the inter-

mediate stages of the trajectories. Numerical integration of the equations of motion including a *Magnus* lifting force produced good agreement with experiment. Typical spin rates were on the order of several hundred revolutions per second and some limited experimental proof is presented verifying this. Average values and frequency distributions for liftoff and impact angles are also presented. The average liftoff and impact angle for the experiments was 50° and 14°, respectively. A semi-empirical procedure for determining the average trajectory associated with given conditions is developed.

(*h*) **Magnus Effect in Saltation,** B. R. White, J. C. Schulz, *J. Fluid Mechanics*, in press, 1977.
Estimated Grain Saltation in a Martian Atmosphere, B. R. White, R. Greeley, J. D. Iversen, J. B. Pollack, *J. Geophysical Research* **81,** 32, pp. 5643-5650, 1976.
Particle Motion in Atmospheric Boundary Layers on Earth and Mars, B. R. White, J. D. Iversen, R. Greeley, J. B. Pollack, *NASA Tech. Memo. TM-X-62*, 463 pages, 1975.
Dust Storms on Mars, R. Greeley, B. R. White, J. D. Iversen, J. D. Pollack, R. N. Leach, *Desert Dust Symposium, Proc. Amer. Assoc. for the Advancement of Science*, 1977.
Mars: Wind Friction Speeds for Particle Movement, R. Greeley, B. R. White, R. N. Leach, J. D. Iversen, J. B. Pollack, *Geophysical Research Letters* **3,** 8, pp. 417-220, 1976.
Note: Any single copy of these publications may be obtained from the first author.

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UNIVERSITY OF CALIFORNIA, LOS ANGELES, School of Engineering and Applied Science, Engineering Systems Department, Los Angeles, Calif. 90024. Dr. William Yeh.

023-07928-820-00

OPTIMAL MANAGEMENT OF LEAKY AQUIFER SYSTEMS

(*c*) Professor W. W-G. Yeh.
(*d*) Basic and applied research.
(*e*) Investigate and test the applicability of control theoretic techniques for optimal management of leaky aquifer systems. The hydraulic conductivities as well as the storage coefficient of the system are generally unknown and are to be identified from field pumping data. Identification of the mathematical structures of layered aquifers is an essential prerequisite for efficient management of ground water basins.
(*f*) Completed.
(*h*) **Aquifer Parameter Identification,** W. W-G. Yeh, *J. Hydraulics Div., ASCE* **101,** HY9, pp. 1197-1209, Proc. Paper 11582, Sept. 1975.
Optimal Identification of Parameters in an Inhomogeneous Medium with Quadratic Programming, W. W-G. Yeh, *Soc. Petroleum Engrgs. J.* **15,** 5, pp. 371-375, Oct. 1975.
The Galerkin Method for Nonlinear Parabolic Equations of Unsteady Groundwater Flow, Y. S. Yoon, W. W-G. Yeh, *Water Resources Research* **11,** 5, pp. 751-754, Oct. 1975.
A Proposed Algorithm for the Solution of the Large-Scale Inverse Problem in Groundwater, S. Chang, W. W-G. Yeh, *Water Resources Research* **12,** 3, pp. 365-374, June 1976.
Parameter Identification in an Inhomogeneous Medium With the Finite-Element Method, Y. S. Yoon, W. W-G. Yeh, *Soc. Petroleum Engrgs. J.*, pp. 217-226, Aug. 1976.
A Systematic Optimization Procedure for the Identification of Inhomogeneous Aquifer Parameters, W. W-G. Yeh, Y. S. Yoon, *Advances in Groundwater Hydrology*, American Water Resources Assoc., Sept. 1976.

023-08701-860-33

OPTIMIZATION OF REAL TIME DAILY OPERATION OF A MULTIPLE-RESERVOIR SYSTEM

(*b*) Office of Water Resource and Technology, USDI.
(*c*) Professor W. W-G. Yeh.
(*d*) Basic and applied research.
(*e*) To develop practical procedures for the analysis of The California Central Valley Project Reservoir System to guide real-time daily decisions concerning the optimal operation of this reservoir system with due regard to multiple-purpose objectives involved and the problems related to hydrologic uncertainties.
(*f*) Completed.
(*g*) See publications.
(*h*) **Optimization of Real-Time Daily Operation of a Multiple Reservoir System,** W. W-G. Yeh, L. Becker, *Proc. 2nd Symp. Water Resources Systems*, Czechoslovak Scientific and Technical Soc., Sept. 1976.
Operations Models for Central Valley Project, L. W. Becker, W. G. Yeh, D. Fults, D. Sparks, *J. Water Resources Planning and Management Div., ASCE* **102,** WRI, pp. 101-115, Apr. 1976.
Optimization of Real-Time Daily Operation of a Multiple Reservoir System, W. G. Yeh, et. al., *UCLA Engrg. Rept. No. UCLA-ENG-7628*, Apr. 1976.

023-10608-860-33

OPTIMIZATION OF REAL-TIME HOURLY OPERATIVE OF A COMPLEX, MULTIPLE PURPOSE RESERVOIR SYSTEM

(*b*) Office of Water Research and Technology.
(*c*) Professor W. W-G. Yeh.
(*d*) Basic and applied research.
(*e*) Develop an hourly optimization model for the entire California Central Valley Project for use in the decision-making process concerning the management and real-time operation of this reservoir system with due regard to the multiple purpose objective involved and the problems related to hydrological uncertainties.
(*g*) See publications.
(*h*) **A Nonlinear Programming Algorithm for Real-Time Hourly Reservoir Operations,** W. S. Chu, W. W-G. Yeh, submitted to *Water Resources Bulletin*, 1977.
Optimization of Real-Time Hourly Operations of a Single Reservoir System by Nonlinear Duality Theorems and Lagrangian Procedures, W. S. Chu, *M. S. Thesis*, directed by W. W-G. Yeh, School of Engrg. and Applied Science, UCLA, Dec. 1976.

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UNIVERSITY OF CALIFORNIA, SAN DIEGO, Scripps Institution of Oceanography, (see SCRIPPS INSTITUTION OF OCEANOGRAPHY listing).

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UNIVERSITY OF CALIFORNIA, SANTA BARBARA, College of Engineering, Department of Chemical and Nuclear Engineering, Santa Barbara, Calif. 93106. Dr. Robert G. Rinker, Department Chairman.

024-10111-020-00

TURBULENT CONVECTIVE TRANSPORT

(*c*) Professor O. C. Sandall or O. T. Hanna.
(*d*) Applied research; theoretical and experimental; Master's and Doctor's theses.
(*e*) Studies of turbulent heat and mass transfer for small diffusivities; non-Newtonian and chemical reaction effects.
(*g*) Successful correlation of theory and experiment has been achieved for fully developed flow conditions.
(*h*) **Turbulent Non-Newtonian Transport in a Circular Tube,** O. C. Sandall, O. T. Hanna, M. Gelibter, *AIChE J.* **22,** 6, Nov. (1976).
Developed Turbulent Transport in Ducts for Large Prandtl or Schmidt Numbers, O. T. Hanna, O. C. Sandall, *AIChE J.* **18,** 527 (1972).

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CALSPAN CORPORATION, P.O. Box 235, Buffalo, N.Y. 14221. Robert S. Kelso, President.

025-09898-870-36

METHODS TO TREAT, CONTROL AND MONITOR HAZARDOUS MATERIAL SPILLS (HASP I & II)

(*b*) Contract Nos. 68-01-0110 and 68-03-0287, EPA.
(*c*) Roland J. Pilié, Head, Environmental and Energy Systems Department.
(*d*) Applied research; laboratory and field.
(*e*) Objective of the HASP I program was to develop new and effective methods to prevent spilled materials from reaching watercourses and to treat, control and monitor spills of hazardous materials into the watercourses. A dry powder was developed which converts virtually any liquid into a thick, viscous mass. Field tests demonstrated that this material, "the multipurpose gelling agent," is extremely useful for immobilizing liquids spilled on land, thereby arresting surface flow and percolations and improving the effectiveness of booms against floating liquids that are immiscible with water.
Objective of the HASP II project was the field testing of a cyclic colorimeter, a wide-spectrum pollutant sensor developed at Calspan. The device was installed next to a creek in Western New York and exposed to the normal hazards encountered in unattended monitoring service. Random spills of a pollutant simulant were used to test the accuracy and reliability of the device. Satisfactory performance of the cyclic colorimeter was observed with weekly maintenance and resupply. Sensitivity, as gauged by noise level, averages one part per million for a wide spectrum of heavy metal pollutants in the version of the apparatus that was being tested.
(*f*) Completed.
(*g*) For spills in watercourses, carbon adsorption and neutralization techniques were investigated as treatment methods. Also investigated was the precipitation of heavy metals by the addition of sodium sulfide. Methods and instrumentation for detecting and monitoring the presence of hazardous materials in watercourses were developed. Means of disseminating control and treatment agents were found. Logistics and cost factors involved in implementing the treatment methods developed were part of the overall program.
(*h*) **Optimization of Universal Gelling Agent and Development of Means of Applying to Spilled Hazardous Materials,** J. G. Michalovic, C. K. Akers, R. E. Baier, R. J. Pilié, *Proc. 1976 Natl. Conf. Control of Hazardous Material Spills*, New Orleans, La., Apr. 25-28, 1976.
Universal Gelling Agent for the Control of Hazardous Liquid Spills, R. E. Baier, J. G. Michalovic, V. A. DePalma, R. J. Pilié, *J. Hazardous Materials* **1,** pp. 21-33, 1975/76.
Technology for Managing Spills on Land and Water, D. B. Dahm, R. J. Pilié, *Environmental Science and Technology* **8,** 13, pp. 1076-1079, Dec. 1974.

025-09899-870-36

ASHTABULA OHIO AREA: WATER POLLUTION INVESTIGATION

(*b*) United States Environmental Protection Agency Region V, Contract No. 68-01-1575.
(*c*) Dr. P. M. Terlecky, Jr., Head, Environmental Sciences Section; J. G. Michalovic, Head, Chemical Analysis Section; S. L. Pack, Research Biologist.
(*d*) Applied research.
(*e*) Report has been developed under auspices of the Great Lakes Initiative Contract Program. The purpose of the program was to obtain additional data regarding the present nature and trends in water quality, aquatic life, and waste loadings in areas of the Great Lakes with the worst water pollution problems. The data thus obtained are being used to assist in the development of waste discharge permits under provisions of the Federal Water Pollution Control Act Amendments of 1972 and in meeting commitments under the Great Lakes Water Quality Agreement between the U.S. and Canada for accelerated effort to abate and control water pollution in the Great Lakes. This investigation reports the results of a historical data collection of information concerning the lower Ashtabula River, harbor and near-shore area, a detailed water sampling and biota collection made during 1973 and 1974, and an evaluation of present and future discharges on the water quality and biota of the area.
(*f*) Completed.
(*g*) The quality of water passing through the Ashtabula complex including Fields Brook has been recognized for many years as a serious environmental problem. NPDES permits have been issued during 1973 and 1974 for an industrial complex of nine major industries. Total residual chlorine, mercury, dissolved solids, and metals content appear to be the most serious water quality parameters which affect this area. Measurement of these parameters from the harbor to Fields Brook demonstrate the source of the materials. Commonly observed values of mercury in Fields Brook were 1.3-1.4 μg/l, although measurements as high as 4.3-4.8 μg/l were observed. Total residual chlorine values measured at the Fields Brook mouth ranged from 1-12 mg/l indicating much higher values closer to the source of the discharge. Dissolved solids and conductivity values increased from both the upstream and downstream direction toward Fields Brook. Values of dissolved solids in Fields Brook ranged from 1495 to 1612 mg/l with corresponding conductivity values ranging as high as 1850 μmho/cm. Flushing time calculations for Ashtabula Harbor during low flow conditions indicated near stagnation for late summer. Diatoms and phytoplankton recovered in the harbor and lower river indicated the presence of a eutrophic, pollution tolerant type of community. Cell counts were found to be low, an observation verified by other researchers. Low biomass, low diversity, and dominance of only a few species at each sample station indicated a seriously degraded water quality situation. If the requirements of current NPDES permits are met for the 1976-1977 period, improvements can be expected in the water quality of the area. Further improvement in the reduction of pollutants in the 1977-1983 period is also expected.
(*h*) **The Water Quality and Biota of the Ashtabula River and Harbour Area of Ashtabula, Ohio,** Dr. P. M. Terlecky, J. G. Michalovic, S. L. Peck, *Abstracts, 17th Conf. Great Lakes Research*, pp. 191-192, Aug. 1974.

CHICAGO BRIDGE AND IRON COMPANY, Marine Research and Development, Route 59, Plainfield, Ill. 60544. Mr. W. A. Tam, Director.

026-09013-420-00

WAVE FORCES ON SUBMERGED OBJECTS

(*c*) Dr. S. K. Chakrabarti, Analytical Head.
(*d*) Theoretical, experimental, and encompasses both basic and applied research.
(*e*) Development of mathematical model and computer programs to predict the forces on basic components of offshore drilling platforms and storage tanks; data obtained experimentally to validate the theoretical models, determine hydrodynamic coefficients and flow characteristics around submerged objects. Projects include developing potential flow theory for large objects, inertia and drag forces and lift forces on small tubular members in random orientation.
(*h*) **Second-Order Wave Force on Large Vertical Cylinder,** S. K. Chakrabarti, *J. Waterways, Harbors and Coastal Engrg. Div., ASCE* **101,** Aug. 1975.
Wave Forces on Vertical Circular Cylinder, S. K. Chakrabarti, A. L. Wolbert, W. A. Tam, *J. Waterways, Harbors and Coastal Engrg. Div., ASCE* **102,** May 1976.
Total Forces on a Submerged Randomly Oriented Tube Due to Waves, S. K. Chakrabarti, W. A. Tam, A. L. Wolbert, *Proc. Offshore Tech. Conf.*, Houston, Tex., May 1976.

Wave Interaction with a Submerged Open-Bottom Structure, S. K. Chakrabarti, R. A. Naftzger, *Proc. Offshore Tech. Conf.*, Houston, Tex., May 1976.

UNIVERSITY OF CINCINNATI, Department of Civil and Environmental Engineering, Hydraulic Laboratory, Cincinnati, Ohio 45221. Dr. L. M. Laushey, Department Head; Dr. H. C. Preul, Directing Head, Hydraulic Laboratory.

027-06462-070-00

WATER HAMMER

(*c*) Dr. Louis M. Laushey.
(*d*) Theoretical. Master's thesis.
(*e*) Simplified equations for water hammer in pipe lines.
(*h*) To be published by IAHR; meeting in Baden-Baden, Germany, Aug. 1977.

027-07229-870-36

URBAN RUNOFF CHARACTERISTICS

(*b*) Environmental Protection Agency.
(*c*) Dr. Herbert C. Preul.
(*d*) Theoretical; field measurements; computer modeling.
(*e*) Field data collected from large urban watershed for development and testing of storm water management models.
(*h*) Interim 1st-year report, *EPA Water Poll. Control Res. Series*, 11024 DQU 10/70, Oct. 1970.
Assessment of Urban Runoff Quantity and Quality, H. C. Preul, *Proc. Intl. Sem. Water Resources Instrumentation*, Chicago, June 1974; available from Intl. Water Resources Assoc., P.O. Box 6, Falls Church, Va. 22046.
Infiltration and Antecedent Precipitation, C. N. Papadakis, H. C. Preul, *J. Hydraulics Div., ASCE*, Oct. 1973.
Testing of Methods for Determination of Urban Runoff, C. N. Papadakis, H. C. Preul, *J. Hydraulics Div., ASCE* **99**, Oct. 1973.
Development of Design Storm Hyetographs for Cincinnati, Ohio, H. C. Preul, C. N. Papadakis, *Water Resources Bull.*, American Water Resources Assoc., Apr. 1973.
University of Cincinnati Urban Runoff Model, C. N. Papadakis, H. C. Preul, *J. Hydraulics Div., ASCE* **98,** Oct. 1972.
Final Report, 1974.
Urban Runoff Management, H. C. Preul, *Proc. 2nd World Congress on Water Resources*, New Dehli, India, Dec. 1975, available from IWRA, P.O. Box 6, Falls Church, Va. 22046.
Selection of Critical Design Storm in Urban Runoff Modeling, H. C. Preul, *Proc. Intl. Symp. Water for Arid Lands*, Tehran, Iran, Dec. 1975, available from IWRA, P.O. Box 6, Falls Church, Va. 22046.

027-07934-870-41

TRAVEL OF POLLUTION THROUGH AN AQUIFER

(*b*) U.S. Public Health Service.
(*c*) Dr. Herbert C. Preul.
(*d*) Theoretical; laboratory and field.
(*e*) Measurements for the development of practical methods for the analysis of the transport of pollutants in flow through an aquifer.
(*h*) **Travel of Pollutants Through an Aquifer,** *Proc. Purdue Industrial Waste Conf.*, May 1971.

027-07935-300-36

ESTIMATION OF STREAMFLOW CHARACTERISTICS USING AIRPHOTOS

(*b*) Partly supported by EPA.
(*c*) E. A. Joering and Dr. Herbert C. Preul.
(*d*) Theoretical, laboratory and field.
(*e*) Development of a procedure for estimating a flow duration curve and floods of selected frequency using airphotos.
(*h*) **A Set of Regime Equations for Indirectly Estimating Stream Flow Characteristics,** E. A. Joering, H. C. Preul, *Proc. 1st Intl. Cong. Water Resources*, Chicago, Sept. 1973; available from Intl. Water Resources Assoc., P.O. Box 5691, Milwaukee, Wis. 53211.

027-07936-250-00

VISCOELASTIC BOUNDARY HYDRAULICS

(*c*) Dr. Louis M. Laushey.
(*d*) Experimental and theoretical; Ph.D. dissertation.
(*e*) Waves are developed and measured on a layer of gelatin coating the bed of an open channel. The friction loss in the fluid and the dissipation within the gelatin are measured.
(*f*) Suspended.
(*h*) **Friction Loss Over Viscoelastic Coatings On Open Channels,** E. W. Lindeijer, Jr., L. M. Laushey, *XVth Cong., Intl. Assoc. Hydraulic Research*, Istanbul, Sept. 1973.

027-10082-310-00

FLOOD ROUTING

(*c*) Dr. Louis M. Laushey.
(*d*) Theoretical. Master's thesis.
(*e*) An implicit method for routing flood waves.

027-10083-290-00

FILTRATION

(*c*) Dr. Louis M. Laushey.
(*d*) Theoretical. Master's thesis.
(*e*) Optimization of filter runs with unsteady flow.

CLARKSON COLLEGE OF TECHNOLOGY, Department of Civil and Environmental Engineering, Potsdam, N.Y. 13676. Dr. N. L. Ackermann, Department Chairman.

028-09973-300-00

MATHEMATICAL MODELING OF FLOOD PLAIN

(*c*) Dr. N. L. Ackermann and Dr. H. T. Shen.
(*d*) Theoretical and experimental; applied research.
(*e*) A two-dimensional mathematical model of a river basin is developed where the interaction effects between the flow in the main channel and overbank portions are included. The model will be used to predict flow conditions in a laboratory flume containing a meandering river reach.

028-09974-130-00

MUD FLOWS

(*c*) Dr. N. L. Ackermann and Dr. H. T. Shen.
(*d*) Theoretical and experimental; applied research.
(*e*) The equations of motion are developed for the flow of solid-fluid mixtures such as those which occur during snow avalanches, land slides and mud flows. The constitutive equations are developed using submodels which demonstrate the interactive effects of the solid and fluid portions of the moving mixture. Laboratory scale flow slides are to be produced and analyzed using the theoretical equations developed to the two-component system.

028-09975-860-00

LIMITING NUTRIENT AND TROPHIC LEVEL DETERMINATION OF LAKE OZONIA BY ALGAL ASSAY PROCEDURE

(*c*) Dr. J. V. DePinto.
(*d*) Applied research; M.S. thesis.
(*e*) The algal assay procedure was used to determine the trophic status and limiting nutrient relationships of Lake Ozonia, an Adirondack Park lake. Assays were carried out using both *Selenastrum Capricornutum* and the natural

phytoplankton population. The lake was found to be mesotrophic with low to moderate productivity. Phosphorus was determined to be the primary limiting nutrient. The enriching effect that secondary sewage effluent and septic tank leaching field groundwater would have on the algal standing crop in Lake Ozonia was shown. Phosphorus removal from secondary effluent by precipitation with lime was found to significantly reduce its stimulatory effect. The inverted microscope technique was used to evaluate changes in indigenous lake algal species caused by nutrient additions to batch cultures.
(*f*) Completed.
(*h*) **Limiting Nutrient and Trophic Level Determination of Lake Ozonia by Algal Assay Procedure,** L. T. Lepak, *M.S. Thesis*, Clarkson College of Technology, May 1976.

028-09976-860-00

A PHOSPHORUS BUDGET AND LAKE MODELS FOR LAKE OZONIA

(*c*) Dr. J. K. Edzwald.
(*d*) Applied research; M.S. thesis.
(*e*) This study involved collecting hydrologic and morphologic data for Lake Ozonia so that a phosphorus budget could be developed for the lake. The construction of the phosporus budget included determining and measuring phosphorus inputs to the lake, and measuring phosphorus in the lake and its outlet. Data derived from the phosphorus budget was then used in empirical models developed by Vollenweider, Sakamoto, and Dillon and Rigler to aid in the determination of Lake Ozonia's trophic status.
(*f*) Completed.
(*h*) **A Phosphorus Budget and Lake Models for Lake Ozonia,** P. M. Cangialosi, *M.S. Thesis*, Clarkson College of Technology, May 1976.

028-09977-300-60

EFFECT OF INCREMENTAL REMOVAL OF DAM ON DOWNSTREAM VELOCITY PATTERNS

(*b*) New York State Department of Law.
(*c*) Professor I. L. Maytin and Professor E. T. Misiaszek.
(*d*) Experimental and field investigation.
(*e*) Model testing of various breach configurations and their corresponding effect on downstream surface velocity patterns during flood conditions.
(*f*) Completed.
(*g*) Surface eddies adjacent to a retaining wall downstream of the dam were found to be very sensitive to the position and depth of breach. While current reversals and changes in size and location of eddies were evidenced for the different models tested, only one type of breach caused eddying to be replaced by a strong current close to the wall.

028-09978-300-00

ANALYSIS OF FLOOD PLAIN DISCHARGE MODEL

(*c*) Professor I. L. Maytin.
(*d*) Experimental, (laboratory) Master's thesis.
(*e*) Testing and analysis of a flume model simulating a meandering river and flood plain system. Data generated from this physical model serves as the input to a simultaneous but separate research program to develop a mathematical model for flood flows in river basins.

028-09979-420-00

EFFECTS OF UNIFORM CURRENT ON WAVE FORCES

(*c*) Dr. H. T. Shen.
(*d*) Theoretical; applied research.
(*e*) The effect of uniform current on wave forces is being studied. The force acting on coastal structures when both waves and currents are presented is being calculated. The body surface boundary condition and the free surface boundary condition will be satisfied exactly to the first-order in the infinitesimal-wave approximation. Diffraction theory and integral equation techniques are used in the analysis.

028-09980-020-00

MATHEMATICAL MODELS FOR TRANSIENT MIXING IN NATURAL CHANNELS

(*c*) Dr. H. T. Shen.
(*d*) Applied research.
(*e*) Analytical and numerical models for mixing of nonconservative dispersants in natural channels is being developed. Effects of channel irregularities are considered by using an orthogonal curvilinear (stream-tube) coordinate system.
(*h*) **Line Source Dispersion with Application to Mixing in River Channels,** H. T. Shen, to appear in *Water Resources Bulletin*, 1977.

028-09981-020-00

THE EFFECT OF ICE COVER ON VERTICAL MIXING IN CHANNELS

(*c*) Dr. H. T. Shen.
(*d*) Applied research; M.S. thesis.
(*e*) A two-dimensional numerical solution is used to study the effect of ice cover on vertical mass transfer in channels based on available field data on flow distributions.

028-09982-070-00

DISPERSION IN POROUS MEDIA FLOW

(*c*) Dr. H. T. Shen.
(*d*) Theoretical; applied research.
(*e*) Analytical solutions are being developed for dispersion in porous media flow. Dispersion of reactive solutes from sources of finite dimension is studied. Similarity behaviours of the dispersion phenomena are being examined.
(*h*) **Transient Dispersion in Uniform Porous Media Flow,** H. T. Shen, *J. Hydraulics Div., ASCE* **102**, HY6, pp. 707-716, June 1976.

COLORADO SCHOOL OF MINES, Basic Engineering Department, Golden, Colo. 80401. Professor R. R. Faddick.

029-08131-130-70

RHEOLOGY OF MINERAL SLURRIES

(*b*) Commercial.
(*d*) Applied research.
(*e*) Rheological data are being measured for predicting headlosses for such slurries as coal-oil, coal-methanol, copper tailings and iron tailings.
(*g*) Most mineral slurries are yield pseudoplastic.
(*h*) **Mineral Slurry Rheology,** presented *Joint Meeting U.S. and Japanese Societies of Rheology*, Honolulu, Hawaii, June 6, 1975.

029-10279-260-88

OPTIMIZATION OF PARTICLE SIZE DISTRIBUTION FOR COAL SLURRY PIPELINES

(*b*) Colorado Energy Research Institute.
(*d*) Theoretical.
(*e*) A technique for optimizing a particle size distribution for coal slurry pipelines was developed for digital computer.
(*f*) Completed.
(*g*) Optimum particle size distribution is a function of solids throughput, pipe length, preparation and separation techniques, and slurry flow regime.
(*h*) **Optimization of Particle Size Distribution for Coal Slurry Pipelines,** R. R. Faddick, G. S. DaBai, presented *Slurry Transportation Assoc.*, Las Vegas, Nev., Mar. 2-4, 1977.

029-10280-260-47

TRANSPORTATION OF TUNNEL MUCK BY PIPELINE

(*b*) U.S. Department of Transportation.
(*d*) Theoretical.

(*e*) Pneumatic and hydraulic pipelines were studied as a means of hauling muck from rapid transit tunnels excavated by tunnel boring machines.
(*g*) Pneumatic and hydraulic pipelines are technically feasible systems for muck removal but economic feasibility requires costing of dewatering systems for hydraulic pipelines and operating costs for pneumatic pipelines.
(*h*) **Transportation of Tunnel Muck by Pipeline,** R. R. Faddick, J. W. Martin, *TSC Rept.*, U.S. Dept. Transportation, Cambridge, Mass., June 1977.

029-10281-260-47

EXPERIMENTAL VERIFICATION OF A PNEUMATIC TRANSPORTATION SYSTEM FOR THE RAPID EXCAVATION OF TUNNELS

(*b*) U.S. Department of Transportation.
(*d*) Experimental.
(*e*) Operating cost and equipment wear were evaluated for a pneumatic pipeline system 600 ft long, 10 inches in diameter transporting 100 tons/hr of stones and gravel.
(*g*) Data analysis incomplete.
(*h*) **Testing of a Pneumatic Muck Transport System,** R. R. Faddick, presented *2nd Ann. Conf. DOT Research and Development in Tunneling Technology*, Easton, Md., Sept. 16, 1976.

COLORADO STATE UNIVERSITY, ENGINEERING RESEARCH CENTER, College of Engineering, Foothills Campus, Fort Collins, Colo. 80521. Dr. D. B. Simons, Associate Dean, Engineering Research Center.

030-07001-810-05

SIMULATION OF HYDROLOGIC SYSTEMS

(*b*) Cooperatively with U.S. Dept. Agriculture.
(*c*) Dr. D. A. Woolhiser, Hydraulic Engineer, USDA-ARS.
(*d*) Theoretical and experimental; basic and applied.
(*e*) Develop procedures for numerically simulating the surface runoff hydrograph of small watersheds and objective techniques for transforming complex watersheds into simple combinations of overland flow planes and channels for numerical simulation.
(*g*) The mathematical model of surface runoff developed earlier has been modified to include erosion and sediment transport. The model is capable of examining the effects of engineering works such as terraces and diversions on erosion. A 41 ft by 4 ft erosion flume has been completed and several data sets are available for model testing. Hydrologic instrumentation has been installed in two small watersheds, one mined and the other unmined, near Steamboat Springs, Colorado. Three stream gaging and water quality sampling stations have been installed on Fish Creek, a tributary of the Yampa River in Northwestern Colorado. The computer program for the kinematic cascade surface runoff model with infiltration has been completely rewritten to improve its computational efficiency, to simplify input, and to provide several options for output. The detailed program documentation is almost complete. It has been demonstrated that nonlinear runoff models are more sensitive to errors in estimation of rainfall excess than linear models. This implies that a linear model may be preferable to the physically more realistic nonlinear model if the infiltration component may have significant errors.
(*h*) **Watershed Sediment Yield–A Stochastic Approach. Present and Prospective Technology for Predicting Sediment Yields and Sources,** D. A. Woolhiser, P. H. Blinco, *USDA ARS-S-40*, pp. 264-273 (June 1975).
Control of Water Pollution from Cropland. Vol. I. A Manual for Guideline Development, B. A. Stewart, D. A. Woolhiser, W. H. Wischmeier, J. H. Caro, M. H. Frere, *Rept. No. ARS-H-5-1; EPA-600/2-75-026a*, 111 pages (Nov. 1975).
Influence of Simplifications in Watershed Geometry in Simulation of Surface Runoff, L. J. Lane, D. A. Woolhiser, V. Yevjevich, *Hydrology Paper No. 81*, Colorado State Univ., Fort Collins, Colo., pp. 50 (Dec. 1975).
Control of Water Pollution from Cropland. Volume II. An Overview, B. A. Stewart, D. A. Woolhiser, W. H. Wischmeier, J. H. Caro, M. H. Frere, *Rept. No. ARS-H-5-2; EPA-600/2-75-026b*, 187 pages (June 1976).
Nonlinear Kinematic Wave Model for Watershed Surface Runoff, V. P. Singh, D. A. Woolhiser, *J. Hydrology* **31,** 3/4, pp. 221-243 (Dec. 1976).
Sensitivity of Linear and Nonlinear Surface Runoff Models to Input Errors, V. P. Singh, D. A. Woolhiser, *J. Hydrology* **29,** 3/4, pp. 243-249 (Apr. 1976).
Stochastic Structure of the Local Pattern of Precipitation, P. Todorovic, D. A. Woolhiser, Chapter 15 in *Stochastic Approaches to Water Resources* **II,** H. W. Shen, Ed., Pub., P.O. Box 606, Fort Collins, Colo. (1976).

030-07247-800-00

WATER RESOURCES OPTIMIZATION

(*b*) Colorado State University, Agricultural Experiment Station.
(*c*) Dr. E. V. Richardson, Professor of Civil Engineering.
(*d*) Experimental, theoretical; applied research and development.
(*e*) To research and apply methods to optimization of the water resources of Colorado. Studies include methods of reducing water loss by seepage, evaporation or transportation; to improve efficiency of the distribution systems by consolidation of conveyance systems; application of linear and dynamic programming, and design of conveyance systems.
(*g*) See (h).
(*h*) **The Design of Spurs for River Training,** E. V. Richardson, M. A. Stevens, D. B. Simons, *Proc. IAHR XVI Congress*, Sao Paulo, Brazil, July 1975.
Mathematical Model of Flow in a Stream Aquifer System, C. E. K. Rovey, E. V. Richardson, *Symp. Modeling Techniques* **1,** *ASCE*, Sept. 1975.
Exclusion and Ejection of Sediment from Canals, A. M. Melone, E. V. Richardson, D. B. Simons, *Colo. State Univ., Dept. of Civil Engrg. Publ.*, Apr. 1975.
Stability of Earth Cover Overlying PVC Membranes, R. Drury, *M.S. Thesis*, Colo. State Univ., June 1975.
Channel Improvements of the Missouri River, E. V. Richardson, H. Christian, *Proc. 3rd Federal Interagency Sediment Conf.*, Denver, Colo., Mar. 1976.
Regional Flood Maxima, P. H. Carrigan, Jr., *Ph.D. Dissertation*, Colo. State Univ., Summer 1975.
The Development of Turbulent Boundary Layers in Open Channel Flow, W. S. Liang, *Ph.D. Dissertation*, Colo. State Univ., Fall 1975.
Mathematical Model of Water Allocation Methods, R. L. Thaemert, *Ph.D. Dissertation*, Colo. State Univ., Spring 1976.

030-08802-300-34

A STUDY OF THE GEOMORPHOLOGY OF THE UPPER MISSISSIPPI RIVER

(*b*) U.S. Department of Interior, Fish and Wildlife Service, St. Paul, Minnesota.
(*c*) D. B. Simons.
(*d*) Theoretical with field investigations, and applied research.
(*e*) Information has been assimilated on the past and present geomorphic features in Pool 1 through Pool 10 in the Upper Mississippi River and its major tributaries, with emphasis on Pool 4 below Lake Pepin in the Mississippi and Chippewa Rivers. The principal components of the geomorphic processes have been identified along with those changes induced by man's activities. Future geomorphic changes which will occur from past, present and planned future development and alternatives thereto

have been predicted by employing a one-dimensional water and sediment routing model.

(*f*) Completed.

(*g*) See (h).

(*h*) **The River Environment,** D. B. Simons, P. F. Lagasse, Y. H. Chen, S. A. Schumm, *Rept. No. CER75-76 DBS-PFL-YHC-SAS* **14,** Civil Engrg. Dept., Colorado State Univ., Fort Collins, Colo., Dec. 1975.

A Summary of the River Environment, D. B. Simons, Y. H. Chen, P. F. Lagasse, S. A. Schumm, *Rept. No. DBS-YHC-PFL-SAS 18*, Civil Engrg. Dept., Colorado State Univ., Fort Collins, Colo., June 1976.

A Geomorphic Study of Pool 4 and Tributaries of the Upper Mississippi River, D. B. Simons, S. A. Schumm, Y. H. Chen, R. M. Beathard, *Rept. No. CER76-77 DBS-SAS-YHC-RMB 11*, Civil Engrg. Dept., Colorado State Univ., Fort Collins, Colo., Oct. 1976.

A Mathematical Model Study of Pool 4 in the Upper Mississippi River and Lower Chippewa Rivers, D. B. Simons, Y. H. Chen, *Rept. No. CER76-77 DBS-YHC 8*, Civil Engrg. Dept., Colorado State Univ., Fort Collins, Colo., Oct. 1976.

A Mathematical Model Study of the Upper Mississippi River Basin, Y. H. Chen, D. B. Simons, *Proc. 1st Intl. Conf. Mathematical Modeling*, St. Louis, Mo., 1977.

030-08804-220-06

DEVELOPMENT OF MODELS FOR PREDICTING SEDIMENT YIELD FROM SMALL WATERSHEDS

(*b*) U.S. Dept. of Agriculture, Rocky Mountain Forest and Range Experiment Station, Flagstaff, Ariz.

(*c*) D. B. Simons.

(*d*) Theoretical with field investigations; basic and applied research.

(*e*) Development of prediction models for estimating sediment yield from a broad spectrum of source areas and watersheds. The prediction models have been tested on study areas with the Coconino National Forest in Arizona, Ice Cream Creek Watershed in California and Mature Upland Pine-Hardwood Watershed in Mississippi.

(*f*) Completed.

(*g*) See (h).

(*h*) **On Overland Flow Water Routing,** R. M. Li, D. B. Simons, M. A. Stevens, *Proc. Natl. Symp. Urban Hydrology and Sediment Control*, Lexington, Ky., July 1975.

Watershed Segmentation by A Digital Computer for Mathematical Modeling of Watershed Response, D. B. Simons, R. M. Li, *Colorado State Univ. Rept. CER75-76DBS-RML9*, Dec. 1975.

Water and Sediment Routing from Small Watersheds, R. M. Li, M. A. Stevens, D. B. Simons, *Proc. 3d Interagency Sedimentation Conf.*, Denver, Colo., Mar. 22-25, 1976.

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Mathematical Modeling of Overland Flow Soil Erosion, R. M. Li, D. B. Simons, D. R. Carder, presented *National Soil Erosion Conf.*, Purdue Univ., West Lafayette, Ind., May 24-26, 1976.

A Simple Method for Quick Estimation of Sediment Yield, D. B. Simons, A. J. Reese, R. M. Li, T. J. Ward, presented *Natl. Soil Erosion Conf.*, Purdue Univ., West Lafayette, Ind., May 24-26, 1976.

Computer Simulation of Storm Water and Sediment Hydrographs from Small Watersheds, R. M. Li, D. B. Simons, D. R. Carder, presented *1976 Summer Computer Simulation Conf.*, Washington, D.C., July 12-14, 1976.

Computer Application in Mapping Potential Landslide Sites, D. B. Simons, T. J. Ward, R. M. Li, presented *1976 Summer Computer Simulation Conf.*, Washington, D.C., July 12-14, 1976.

Solutions to Green-AMPT Infiltration Equation, R. M. Li, M. A. Stevens, D. B. Simons, *J. Irrigation and Drainage Div., ASCE* **102,** IR2, pp. 239-248, June 1, 1976.

Morphology of Cobble Streams in Small Watersheds, R. M. Li, D. B. Simons, M. A. Stevens, *J. Hydraulics Div., ASCE* **102,** HY8, pp. 1101-1117, Aug. 1976.

On Kinematic Wave Approximation For Flood Routing, R. M. Li, D. B. Simons, L. S. Shiao, Y. H. Chen, *RIVERS* **76,** 1, *3rd Ann. Symp. on Inland Waterways for Navigation, Flood Control and Water Diversion*, Colorado State Univ., Fort Collins, Colo., pp. 377-398, Aug. 1976.

Modeling of Sediment and Water Routing and Yield at Colorado State University, D. B. Simons, R. M. Li, T. J. Ward, presented *USDA Forest Service, Earth Science Symp.*, Fresno, Calif., Nov. 8-12, 1976.

Process Model of Infiltration and Subsurface Flow Routing, R. M. Li, D. B. Simons, K. G. Eggert, *Colorado State Univ. Rept. CER76-77RML-DBS-KGE 20*, Dec. 1976.

Preliminary Procedural Guide for Estimating Water and Sediment Yield from Roads in Forests, D. B. Simons, R. M. Li, L. Y. Shiao, *Colorado State Univ. Rept. CER76-77DBS-RML-LYS 21*, Nov. 1976.

Simple Procedural Method for Estimating On-Site Soil Erosion, D. B. Simons, R. M. Li, T. J. Ward, *Colorado State Univ. Rept. CER76-77RML-DBS-TJW 38*, Feb. 1977.

A Mathematical Model for Evaluating On-Site Soil Erosion, R. M. Li, D. B. Simons, R. K. Simons, *Colorado State Univ. Rept. CER76-77-RML-DBS-RKS 40*, Feb. 1977.

Formulation of Road Sediment Model, D. B. Simons, R. M. Li, L. Y. Shiao, *Colorado State Univ. Rept. CER76-77DBS-RML-LYS 50*, Mar. 1977.

030-10333-220-13

INVESTIGATION OF THE EFFECTS OF CHIPPEWA RIVER EROSION AND SILT REDUCTION MEASURES

(*b*) D. B. Simons and Y. H. Chen.

(*d*) Theoretical with field investigations and applied research.

(*e*) Past and present geomorphic features of Pool 4 below Lake Pepin in the Upper Mississippi River and the Chippewa River below Eau Claire have been investigated. This information coupled with a one-dimensional water and sediment routing model has been utilized to examine alternative measures to determine how effectively they reduce sediment supply from the Chippewa River to the Mississippi River navigation channel and backwater areas; and to investigate the effects of each alternative on aggradation and degradation in the Chippewa River.

(*f*) Completed.

(*g*) See (h).

(*h*) **Investigation of the Effects of Chippewa River Erosion and Silt Reduction Measures,** D. B. Simons, Y. H. Chen, *Rept. No. CER 76-77-DBS-YHC 54*, Civil Engrg. Dept., Colorado State Univ., Fort Collins, Colo., May 1977.

030-10334-220-34

STUDY OF THE UPPER MISSISSIPPI RIVER SYSTEM

(*b*) U.S. Department of the Interior, Fish and Wildlife Service, St. Paul, Minnesota.

(*c*) D. B. Simons and Y. H. Chen.

(*d*) Field investigation, basic and applied research.

(*e*) A two-dimensional mathematical model for study of water and sediment movement in a river system is being developed. This model will be applied to predict detailed geomorphic changes in the Lower Pool 4 reach and the lower end of the Chippewa River caused by various development activities and thus identify successful development projects in the study reach that meet the goals of flood control, recreation, conservation of resources, and preservation or enhancement of the environment as well as navigation.

030-10335-370-70

VIBRATION TESTS OF THERMAL WELLS

(*b*) Powers Regulator Company, Skokie, Illinois.

(*c*) Y. H. Chen.

(*d*) Applied research.

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(*e*) Six thermal wells have been tested in pipeline systems utilizing water as the liquid. The objective of the study is to obtain the necessary information for designing thermal wells to avoid their failure due to stresses induced by the flow.
(*f*) Completed.
(*g*) See (h).
(*h*) **Vibration Tests of Thermal Wells,** Y. H. Chen, R. P. Vandenberg, D. B. Simons, *Rept. No. CER 76-77 YHC-RPV-DBS 7,* Civil Engrg. Dept., Colorado State Univ., Fort Collins, Colo., Sept. 1976.
Vibration of Thermal Wells in Pipeline Systems, Y. H. Chen, D. B. Simons, *Proc. XVIIth Intl. Congress of the IAHR,* Baden-Baden, Germany, 1977.

030-10336-810-33

QUANTIFICATION OF HYDROLOGICAL IMPACTS FOR URBAN GROWTH MANAGEMENT STUDIES

(*b*) OWRT.
(*c*) Neil S. Grigg.
(*d*) Applied research.
(*e*) The hydrological effects of urbanization include both the quantity and quality aspects of surface runoff. Surface runoff peaks increase in magnitude and appear quicker due to urbanization, and a great deal of pollution results from the washing of contaminated surfaces. Communities are aware of these problems and are taking action to mitigate their effects. Opportunities for control of both pollution and flooding are at their peak prior to the completion of the urban growth phase. Communities are now aware more than ever before of the need for growth management. A typical case in the front range urban corridor, Colorado, will be used to test a number of techniques which have already been developed for related purposes (urban drainage and flood control) and which may have useful application for rational growth management.

030-10337-820-54

METHODOLOGIES FOR COST-EFFECTIVE GROUNDWATER DEVELOPMENT

(*b*) NSF.
(*c*) W. A. Hall and J. W. Labadie.
(*d*) Applied research.
(*e*) Groundwater is extensively used for water supplies throughout the United States. In some areas it is the only source of supply. One of the most difficult problems in development of new or sparsely developed groundwater resources is the difficulty of estimating groundwater basin characteristics in advance of costly well drilling programs. The purpose of this proposed research is two-fold: first, to develop and test methodologies which will optimize the number and placement of wells in an untapped or underdeveloped groundwater basin; and second, to study the theoretical characteristics of the response of groundwater basins to a variety of unorthodox stimuli which might give more extensive information on aquifer characteristics.

030-10338-220-13

SEDIMENTATION STUDY OF THE UPPER AUXILIARY PROJECT WITHIN THE YAZOO RIVER BASIN AND DEVELOPMENT OF A MATHEMATICAL MODEL

(*b*) U.S. Department of the Army, Corps of Engineers, Vicksburg District, Vicksburg, Mississippi.
(*c*) D. B. Simons.
(*d*) Theoretical with field investigations; applied research.
(*e*) A study is being conducted to evaluate various development plans for channel improvement in the Yazoo River Basin, Mississippi. The plans for improvement include construction of a cross-country channel in Tallahatchie, Lefore and Humphreys counties to provide additional channel capacity to pass flood waters from the upper basin. The study involves a systems analysis using mathematical models of the main channel and its tributaries in such a way that water and sediment is routed from the watershed and through the main channel to determine the effectiveness of the system considering flood control, navigation and the location of aggradation and degradation in the main channel and its tributaries and methods of minimizing these and related problems. The analysis provides a means of evaluating various design alternatives to determine the best plan for development.

030-10339-810-06

DEVELOPMENT, FIELD TESTING, DOCUMENTATION OF PROCEDURES FOR DETERMINING MODEL PARAMETERS, FOR MODEL SIMPLIFICATION OF WATER AND SEDIMENT ROUTING AND YIELD MODELS, AND FOR MAPPING POTENTIAL LANDSLIDE AREAS

(*b*) U.S. Department of Agriculture, Rocky Mountain Forest and Range Experiment Station, Flagstaff, Arizona.
(*c*) D. B. Simons; R. M. Li.
(*d*) Theoretical with field investigations; basic and applied research.
(*e*) This is a continuation of the effort on the development of a comprehensive ecological system component simulation model. The specific objectives of this study are: 1) Develop, field test, and document a procedure for determining the channel geometry of a large watershed utilizing aerial photographs. The field test site would be Woods Canyon Watershed, Coconino National Forest, Arizona. 2) Develop, field test, and document a procedure for the infield estimation of infiltration parameters. 3) Develop, test, and document a simple procedural method for evaluating water and sediment yields from small watersheds. 4) Develop, test, and document a simple water routing and yield model for determining water hydrographs using a hand-held programmable calculator. 5) Develop, test, and document a procedure for mapping potential landslide hazard areas in terms of slope stability. The study site would be H. J. Andrews Watershed, Oregon.
(*g*) See (h).
(*h*) **Simple Water Routing and Yield Model Using a Small Programmable Calculator,** D. B. Simons, R. M. Li, K. G. Eggert, *Colorado State Univ. Rept. CER76-77DBS-RML-DKE 52,* Apr. 1977.

030-10340-220-06

FIELD TESTING AND REFINEMENT OF A QUANTITATIVE ROAD SEDIMENT MODEL

(*b*) U.S. Department of Agriculture, Rocky Mountain Forest and Range Experiment Station, Flagstaff, Arizona.
(*c*) D. B. Simons; R. M. Li.
(*d*) Theoretical with field investigations; basic and applied research.
(*e*) Test and refine a numerical model of soil loss and storm runoff from timber access roads with the goal of providing a useful predictive model for use in road planning, maintenance, location design and environmental impact evaluation. The model will be tested on two road erosion study sites currently being operated by Coweeta Hydrologic Laboratory near Franklin, North Carolina. These test sites are collecting soil losses from the cut slope, fill slope, and road bed separately. The cut and fill slopes will have two different surface conditions with and without vegetation. The roadbed will also have two different surface conditions with and without gravel surfacing. Approximately 30 storms will be studied. These storms will range from those of low intensity and long duration in the winter months to those of high intensity and short duration in the summer months.

030-10341-200-54

SPATIAL AND TIME DISTRIBUTION OF BOUNDARY SHEAR STRESS IN OPEN CHANNEL FLOWS

(*b*) National Science Foundation.
(*c*) D. B. Simons; R. M. Li.
(*d*) Experimental and theoretical investigation; basic research.
(*e*) This study of the spatial and statistical distribution of the instantaneous boundary shear stress in smooth uniform open channels consists of both experimental and analytical

investigations. The specific objectives are investigation of the spatial variation of the probabilistic distribution and statistical moments of the boundary shear stress in simple prismatic channels with varying flow conditions; determine the influence of the channel geometry and flow variables on the probability distribution parameters; investigate the significance of secondary flow on the probabilistic distribution of the shear stress in terms of both channel geometry and hydraulic flow conditions; correlate the probability distribution parameters with the gross hydraulic conditions and channel geometry parameters; study the interrelationship of the turbulent velocity pressure structure to the shear stress process; discuss the application of the result to the open channel flow problems.

030-10342-880-36

DEVELOPMENT OF A GENERALIZED PLANNING MODEL FOR EVALUATION OF ALTERNATIVE FOREST MANAGEMENT PRACTICES (ENGINEERING PHASE)

(*b*) Environmental Protection Agency, Athens, Georgia, Environmental Research Laboratory.
(*c*) D. B. Simons, R. M. Li.
(*d*) Theoretical with field investigations; basic and applied research.
(*e*) This is an initial effort to develop a generalized planning model for evaluation of alternative forest management practices as a function of environmental and resource goals. The objectives of this study are to develop and test a water and sediment routing and yield model for both small and large watersheds and for both short and long term periods; to develop and test a process model which will simulate the erosion and deposition of channel banks for unstable channels in forested upland watersheds. To incorporate this process model into the developed water and sediment routing model the remaining objectives will be to develop a procedure for routing forest litter from the land surface for predicting the loading of stream channels with organic debris; to interface on available nitrogen and phosphorous sediment uptake model with the developed water and sediment routing model; to develop a thermal loading model for predicting the temperature and dissolved oxygen of water loading to the stream; and to link the cause-effect process model and the multiple-objective programming model for the selection of forest management alternatives. In order to meet the above mentioned objectives the proposed study will develop numerical models considering the physical significance of the governing processes.

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UNIVERSITY OF COLORADO AT BOULDER, Cooperative Institute for Research in Environmental Sciences (CIRES), Boulder, Colo. 80309. Professor Carl Kisslinger, Institute Director.

031-08812-480-54

DYNAMICS OF ATMOSPHERIC FLOWS

(*b*) National Science Foundation (in part).
(*c*) George Chimonas, Assoc. Director (Atmos. Sci.), CIRES.
(*d*) Basic theoretical research.
(*e*) Micro and meso scale dynamics of atmospheric flows with emphasis of the role of waves. Primary and secondary stability of stratified shear flows, including effects from the presence of water substance. Wave-storm interactions. Formation of meso-lows and rotational storms. Origin of geo-sound.
(*f*) Expanding.
(*h*) **The Propagation of Acoustic-Gravity Waves in a Moist Atmosphere,** F. Einaudi, D. P. Lalas, *J. Atmos. Sci.* **30**, pp. 365-376, Apr. 1973.
On the Stability of a Moist Atmosphere in the Presence of a Background Wind, D. P. Lalas, F. Einaudi, *J. Atmos. Sci.* **30**, pp. 795-800, July 1973.
On the Growth Rate of an Unstable Disturbance in a Gravitationally Stratified Shear Flow, F. Einaudi, D. P. Lalas, *J. Atmos. Sci.* **30**, pp. 1707-1710, Nov. 1973.
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The Effect of Boundaries on the Stability of Inviscid Stratified Shear Flows, F. Einaudi, D. P. Lalas, *J. Appl. Mech.* **98**, pp. 243-248, June 1976.
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Lamb Waves Generated by the 1970 Solar Eclipse, G. Chimonas, *Planet. Space Sci.* **21**, 1843, 1973.
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Consideration of the Stability of Certain Heterogeneous Shear Flows Including Some Inflexion-Free Profiles, *J. Fluid Mech.* **65**, 65, 1974.
A Possible Source Mechanism for Mountain Associated Infrasound, G. Chimonas, *J. Atmos. Sci.*, in press, 1977.
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Infrasonic Waves from Auroral Arcs, G. Chimonas, *J. Geophys. Res.*, in press, 1977.
The Asymmetry in Infra-Sound Generation by Travelling Aurora, G. Chimonas, *J. Atmos. Terr. Phys.*, in press, 1977.
An Observational and Theoretical Study of Shear Instability in the Air Flow Near the Ground, J. Merrill, *Ph.D. Thesis*, Univ. of Colorado, 1976.
On the Stability of Some Fluid Flows, A. Zebib, *Ph.D. Thesis*, Univ. of Colorado, 1975.

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UNIVERSITY OF COLORADO AT BOULDER, College of Engineering and Applied Science, Department of Civil, Environmental and Architectural Engineering, Boulder, Colo. 80309. Dr. George G. Goble, Department Chairman.

032-10776-870-88

DESIGN OF WATER AND WASTEWATER SYSTEMS FOR BOOM TOWNS AND RESORTS

(*b*) Eisenhower Consortium for Western Environmental Forestry Research.
(*c*) Dr. J. Ernest Flack.
(*d*) Applied research; M.S. thesis by Paul Gorder.
(*e*) Development of design criteria for water and wastewater systems for rapid growth areas under adverse climatic conditions.
(*f*) Completed.
(*g*) Handbook available.
(*h*) **Design of Water and Wastewater System,** Environmental Resources Center, Colorado State University, Fort Collins, Colo. 80523 ($4.00).

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UNIVERSITY OF COLORADO AT DENVER, Department of Civil and Urban Engineering, Denver, Colo. 80202. Dr. Ernest Harris, Department Chairman.

033-10777-360-00

THE SIGNIFICANCE OF REVERSE UNDERFLOW ON THE CHARACTERISTICS OF A HYDRAULIC JUMP

(*c*) Dr. William Hughes.
(*d*) Basic research; M.S. thesis by Charles G. Roberts.
(*e*) A study of the effects of reverse underflow through a porous media had on the characteristics of the hydraulic jump.
(*f*) Completed.
(*g*) Bed roughness and reverse flow modify the characteristics of the hydraulic jump: (a) the energy loss is reviewed, (b) the sequent depth and length are modified and, (c) the basic impulse-momentum relationship is not applicable, compared with the jump on a horizontal, smooth bed.

033-10778-220-88

CHANNEL EROSION RISK INDEX

(*b*) Eisenhower Consortium for Western Environmental Forest Research.
(*c*) Dr. William C. Hughes.
(*d*) Applied research.
(*e*) A study to develop a method for assessing the probable risk of future channel erosion based on channel soil condition, slope and design discharge.
(*g*) For a given soil classification, field observations when plotted on a scatter diagram relating discharge to channel slope, divides into regions where scour was always present, scour was never present, and a central band in which the probability of channel scour varies from zero to one.

COLUMBIA UNIVERSITY, Lamont-Doherty Geological Observatory (see Lamont-Doherty Geological Observatory listing).

UNIVERSITY OF CONNECTICUT, Marine Sciences Institute, Groton, Conn. 06340. S. Y. Feng, Institute Director.

034-10115-220-44

AN INVESTIGATION OF THE IMPACT OF DREDGING OPERATIONS ON SUSPENDED MATERIAL TRANSPORT IN THE LOWER THAMES RIVER ESTUARY

(*b*) National Oceanic and Atmospheric Administration Middle Atlantic Coastal Fisheries Center, National Marine Fisheries Service, Highlands, New Jersey.
(*c*) Asst. Professor W. F. Bohlen.
(*d*) Field investigations; basic research.
(*e*) A series of field surveys conducted during the period 1974-1976 have been used to analyze the spatial characteristics of the plume of fine grained materials introduced into the water column by a large volume clam-shell/bucket dredging operation in the lower Thames River near New London, Connecticut. Complementing this three-dimensional map, discrete drawn water samples were obtained to permit determination of the composition and by-weight concentrations. Compositional analyses included particulate organic carbon and grain-size distributions.
(*f*) Completed.
(*g*) Surveys indicate that the impacts of the dredging operation are confined to within 300-500 m of the dredge and spoils barge. In this area suspended material concentrations exceed ambient levels by a factor of thirty and a significant shift in the relative percentage of organics versus inorganics in the suspended load is observed. Comparisons of these characteristics to those produced by naturally occurring storm events indicate that dredging represents a relatively minor factor within the suspended material transport system in the estuary.
(*h*) Final report available. Contact W. F. Bohlen.

034-10116-450-20

DYNAMICS OF OCEANIC FRONTS

(*b*) Office of Naval Research, Ocean Research Office.
(*c*) Assoc. Professor R. W. Garvine.
(*d*) Theoretical modeling; basic research and Ph.D. thesis.
(*e*) A hydrodynamic model of the motion field near an oceanic front is developed. The equations of motion are treated by an integral technique. Both turbulent friction and mass entrainment are included as well as the effects of surface wind stress and earth rotation. The model can be applied to any scale of oceanic front from river plume fronts to the Gulf Stream front.
(*h*) **Dynamics of Small-Scale Oceanic Fronts,** R. W. Garvine, *J. Phys. Oceanogr.* **4,** pp. 557-569, 1974.

CORNELL UNIVERSITY, Department of Environmental Engineering, School of Civil and Environmental Engineering, Ithaca, N.Y. 14853. Daniel P. Loucks, Department Chairman.

035-08674-810-54

THE CALCULATION OF REGIONAL EVAPOTRANSPIRATION BY MEANS OF STANDARD METEOROLOGICAL DATA

(*b*) National Science Foundation.
(*c*) Dr. W. H. Brutsaert.
(*d*) Theoretical and applied research.
(*e*) The investigation deals with the problem of the applicability of recently developed similarity schemes for the parameterization of the atmospheric boundary-layer under adiabatic conditions to the determination of surface vapor flux by means of synoptic meteorological data, which are published regularly or otherwise easily available.
(*h*) **Computing Evapotranspiration by Geostrophic Drag Concept,** J. A. Mawdsley, W. Brutsaert, *J. Hydraulics Div., Proc. ASCE* **99,** pp. 99-110, 1973.
Evaporation from Water Surfaces, W. Brutsaert, in *Interfacial Transfer Processes in Water Resources, Water Resour. and Envir. Engrg. Rept. No. 75-1*, State Univ. N.Y., Buffalo, pp. 99-114, Jan. 1975.
A Theory for Local Evaporation (or Heat Transfer) from Rough and Smooth Surfaces at Ground Level, W. Brutsaert, *Water Resour. Res.* **11,** 4, pp. 543-550, 1975.
The Roughness Length for Water Vapor, Sensible Heat, and Other Scalars, W. Brutsaert, *J. Atmosph. Sciences* **32,** 10, pp. 2028-2031, 1976.
The Applicability of Planetary Boundary Layer Theory to Calculate Regional Evapotranspiration, W. Brutsaert, *Water Resour. Res.* **12,** Oct. 1976.

035-08675-820-00

THE REDUCTION OF GROUNDWATER STORAGE BY SUBSIDENCE

(*c*) Dr. W. H. Brutsaert.
(*d*) Theoretical and applied research.
(*e*) The classical elastic approach has often been inadequate in the case of subsiding aquifers. The present study deals with the applicability of alternative models on the basis of recent developments in soil rheology. The results are tested with field data from the San Joaquin Valley.
(*h*) **Subsidence: The Influence of Man on Groundwater Storage,** M. Y. Corapcioglu, M. Yavuz, W. Brutsaert, *Proc. 3d Intl. Symp. Groundwater*, Palermo, Italy, Nov. 1-5, 1975.
Pumping of Aquifer with Viscoelastic Properties, W. Brutsaert, M. Y. Corapcioglu, *J. Engrg. Mech. Div., Proc. ASCE*, in press, 1976.

035-09938-800-33

INTERACTIVE MULTIOBJECTIVE WATER RESOURCES PLANNING

(*b*) OWRT, USDI.
(*c*) Daniel P. Loucks.
(*d*) Applied research.
(*e*) Use of interactive computer graphics as a means of inputting data and displaying the results of multipurpose, multiobjective water resources optimization and simulation models, and permitting planners and decision makers ways of interacting with such models in the search for the most suitable solution.

035-09939-860-33

AQUATIC ECOSYSTEM MANAGEMENT MODELS

(*b*) OWRT, USDI.
(*c*) Daniel P. Loucks.
(*d*) Applied research.
(*e*) Adaptation of existing multiparameter aquatic water quality simulation models to a form suitable for incorporation into optimization models that can simultaneously consider economic and environmental water quality management policy problems.

035-09940-440-54

FINITE ELEMENT ANALYSIS TO THE POLLUTION ANALYSIS OF LAKES

(*b*) National Science Foundation.
(*c*) James A. Liggett and Richard H. Gallagher.
(*d*) Basic theoretical research.
(*e*) Development of finite element models to compute lake circulation and the dispersion of pollutant in lakes. Also development of the computer graphics software to generate input data and display results.
(*h*) **Finite Element Shallow Lake Circulation Analysis,** R. H. Gallagher, J. A. Liggett, S. T. K. Chan, *J. Hydraulics Div., ASCE*, July 1973.
Transient Finite Element Shallow Lake Circulation, F. D. L. Young, J. A. Liggett, *J. Hydraulics Div., ASCE*, July 1977.
Steady Stratified Circulation in a Cavity, D.-L. Young, J. A. Liggett, R. H. Gallagher, *J. Engrg. Mech. Div., ASCE*, Feb. 1976.
Unsteady Stratified Circulation in a Cavity, D.-L. Young, J. A. Liggett, R. H. Gallagher, *J. Engrg. Mechanics Div., ASCE*, Dec. 1976.
Convective Transport Finite Element Analog, K. W. Bedford, J. A. Liggett, *J. Engrg. Mechanics Div., ASCE*, Dec. 1975.

035-09941-440-44

COASTAL CURRENTS AND SEDIMENT TRANSPORT ON GREAT LAKES SHORELINE

(*b*) NOAA, Sea Grant Program, U.S. Dept. of Commerce.
(*c*) Philip L-F. Liu.
(*d*) Applied research.
(*e*) Examine and modify the existing models for calculating the coastal currents and sediment transports and to develop a complete and flexible model of a system which is suitable for predicting the coastal currents and sedimentary patterns in the New York Great Lakes coastal zone; investigate the water movement in harbors along the Great Lakes shoreline and to study the effectiveness of different types of breakwaters as protective measures for harbor improvements.
(*h*) **Finite Element Modeling of Nearshore Circulation,** P. L-F. Liu, G. Lennon, *Intl. Conf. Applied Numerical Modeling*, July 11-15, 1977.
Effects of Beach Topography on Nearshore Currents, G. P. Lennon, *M.S. Thesis*, Dept. of Environmental Engrg., Cornell University.

035-09942-410-54

FINITE ELEMENT MODELING NEARSHORE CIRCULATIONS

(*b*) National Science Foundation.
(*c*) Philip L-F. Liu.
(*d*) Theoretical basic research.
(*e*) Research investigates effects of waves, beach topography and winds on nearshore circulations.
(*h*) **Effects of Topography on the Circulation In and Near the Surf Zone–Linear Theory,** C. C. Mei, P. L-F. Liu, *J. Estuarine and Coastal Marine Science* 5, pp. 25-37, 1977.
A Perturbation Solution of Non-Linear Diffusion Equations, P. L-F. Liu, *J. Water Resources Res.* **12**, 6, 1976.
On Gravity Waves Propagated Over a Layered Porous Bed, P. L-F. Liu, *Intl. J. Coastal Engrg.* **1**, 1, 1977.
Mass Transport in Water Waves Propagated Over a Permeable Bottom, P. L-F. Liu, *Intl. J. Coastal Engrg.* **1**, 1, 1977.

035-09943-440-80

TURBULENCE MEASUREMENTS IN A LAKE

(*b*) The Engineering Foundation.
(*c*) James A. Liggett and Peter J. Murphy.
(*d*) Basic experimental research.
(*e*) Measurement of eddy diffusivity in a stratified lake.

035-09944-220-54

BEDLOAD MEASUREMENT AND MODELS

(*b*) National Science Foundation.
(*c*) Peter J. Murphy.
(*d*) Basic experimental and theoretical research:
(*e*) Definition and measurement of the bedload movement process.

035-09945-070-54

BOUNDARY INTEGRAL SOLUTIONS TO GROUNDWATER PROBLEMS

(*b*) National Science Foundation.
(*c*) James A. Liggett and Philip L-F. Liu.
(*d*) Basic theoretical research.
(*e*) Development of boundary integral techniques for the solution of a variety of problems in flow in porous media in two and three dimensions. Also development of the computer graphics software to generate input data and display results.
(*h*) **Location of Free Surface in Porous Media,** J. A. Liggett, *J. Hydraulics Div., ASCE*, Apr. 1977.
Boundary Integral Solutions to Groundwater Problems, P. L-F. Liu, J. A. Liggett, *Intl. Conf. Applied Numerical Modeling*, Southhampton, U.K., July 11-15, 1977.
Unsteady Free Surface Flow Through a Zoned Dam Using Boundary Integration, J. A. Liggett, P. L-F. Liu, *Symp. Applications of Computer Methods in Engrg.*, Univ. Southern California, Los Angeles, Aug. 23-26, 1977.

DARTMOUTH COLLEGE, Thayer School of Engineering, Hanover, N.H. 03755. Graham B. Wallis, Prof. of Engineering, Horst J. Richter, Research Assistant Prof. of Engineering.

036-09789-130-73

THE SEPARATED FLOW MODELS OF TWO-PHASE FLOW

(*b*) Electric Power Research Institute.
(*d*) Theoretical and experimental basic research.
(*e*) Establishment of a unified basic theory.
(*h*) **The Separate Flow Model of Two-Phase Flow,** G. B. Wallis, H. J. Richter, J. T. Kuo, *EPRI NP-275*, Dec. 1976.

036-09790-130-55

EFFECT OF SCALE ON TWO-PHASE COUNTERCURRENT FLOW FLOODING IN VERTICAL TUBES

(*b*) NRC.
(*d*) Theoretical and experimental basic research.
(*e*) Obtain data on flooding in various scales.

036-09791-130-55

TECHNICAL ASSESSMENT OF TWO-PHASE FLOW ASPECTS OF NUCLEAR REACTOR SAFETY

(*b*) NRC.
(*d*) Theroetical and experimental modeling of two-phase flow phenomena.

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UNIVERSITY OF DELAWARE, College of Marine Studies, Newark, Del. 19711. Dr. W. S. Gaither, Dean.

037-08855-420-20

PHOTO-OPTICAL DETERMINATION OF SHALLOW WATER WAVE SPECTRA

(*b*) Geography Programs, Office of Naval Research, Department of the Navy.
(*c*) Dr. V. Klemas, Associate Professor.
(*d*) Experimental theoretical and field investigation; applied research.
(*e*) Derivation of shallow water spectra by employing optical Fourier analysis of aerial photographs and correlating with spectra of same waves obtained with airborne laser profiler and wave probes on towers outside the surf zone. Rapid survey of coastal wave conditions for amphibious operations and construction.
(*g*) Field work has been completed and correlation of remotely sensed and ground probe data continues.
(*h*) **Photo-Optical Determination of Shallow-Water Wave Spectra,** V. Klemas, J. Borchardt, L. Hsu, G. Gredell, N. Jensen, *Proc. Intl. Symp. on Ocean Wave Measurement and Analysis*, New Orleans, La., Sept. 9-11, 1974.

037-08856-450-50

SPACECRAFT STUDIES OF COASTAL CURRENT CIRCULATION AND SUSPENDED SEDIMENT CONCENTRATION

(*b*) Earth Resources Satellite and Skylab Programs, National Aeronautics and Space Administration.
(*c*) Dr. V. Klemas, Associate Professor.
(*d*) Experimental, theoretical and field investigation, applied research.
(*e*) Determination of estuarine and shelf current circulation using air-dropped, air-traced drogues and dyes with integrated ship-aircraft-satellite system. Gross circulation patterns are derived from satellite images and correlated with ground measurements. Mapping suspended sediment concentration using digital analysis of ERTS-1 imagery and water samples collected from boats and helicopters. Delaware Bay and overseas sites. Determine identity, location, concentration, movement and dispersion of sludge and acid plumes caused by ocean dumping of wastes.
(*g*) High degree of correlation obtained between satellite image radiance in the red band (band 5) and suspended sediment concentration, inverse Secchi depth, and current circulation in the upper two meters of the water column.
(*h*) **Dye and Drogue Studies of Spoil Disposal and Oil Dispersion,** V. Klemas, D. Maurer, W. Leathem, P. Kinner, W. Treasure, *J. Water Pollution Control Federation* **46,** 8, Aug. 1974, pp. 2026-2034.
Skylab and ERTS-1 Investigations of Coastal Land Use and Water Properties, V. Klemas, D. Bartlett, R. Rogers, *AIAA/AGU Conf. Scientific Experiments of Skylab*, Huntsville, Ala., Oct. 30-Nov. 1, 1974.
Coastal and Estuarine Studies with ERTS-1 and Skylab, *Remote Sensing of Environment* **3,** 153-174, 1974.
Correlation of Coastal Water Turbidity and Circulation with ERTS-1 and Skylab Imagery, V. Klemas, M. Otley, W. Philpot, R. Rogers, *Proc. 9th Intl. Symp. Remote Sensing of Environment*, Apr. 15-19, 1974, Ann Arbor, Mich.

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UNIVERSITY OF DETROIT, College of Engineering, Civil Engineering Department, 4001 W. McNichols Road, Detroit, Mich. 48221. Dr. Eugene Kordyban, Associate Professor.

038-07979-130-00

INVESTIGATION OF THE MECHANISM OF SLUG FORMATION IN TWO-PHASE HORIZONTAL FLOW

(*d*) Experimental and theoretical basic research.
(*e*) Basic nature of wavy and stratified air-water flow is being studied theoretically and experimentally to determine the conditions under which the slugs will form.
(*g*) The wave characteristics such as speed, height to length ratio and the internal flow patterns have been determined experimentally. The wave growth as a function of water depth and air velocity has been established. The criteria for slug formation as a result of wave instability have been found theoretically.
(*h*) **Long Wave Disturbances in Two-Phase Wavy Flow,** E. Kordyban, *ASME Paper 75 WA/HT-28*.
Some Characteristics of High Waves in Closed Channels Approaching Kelvin-Helmholtz Instability, E. Kordyban, *Trans. ASME, J. Of Fluids Engr.* **99,** 1977.
Experimental Techniques in Measuring the Growth of Interfacial Waves, E. Kordyban, S. Cuker, *Cavitation and Polyphase Forum–1976, ASME Publication.*

038-09924-870-00

A STUDY OF THE BEHAVIOR OF AN OIL FILM ON THE SURFACE OF WATER IN THE PRESENCE OF WAVES

(*d*) Basic research, theoretical and experimental.
(*e*) The behavior of a layer of oil on the surface of water in the presence of water is investigated experimentally and analytically.
(*g*) Presently a gage is being developed for the measurement of thickness of an oil layer in the presence of waves.
(*h*) **A Method for Measuring Oil Thickness on the Surface of Water in the Presence of Waves,** E. Kordyban, S. Cuker, *Cavitation and Polyphase Forum–1977, ASME Publication.*

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UNIVERSITY OF FLORIDA, Coastal and Oceanographic Engineering Laboratory, College of Engineering, Gainesville, Fla. 32611.

039-09087-400-54

TRANSVERSE CIRCULATION AND MASS TRANSPORT IN ESTUARIES

(*b*) National Science Foundation.
(*c*) Y. H. Wang.
(*e*) The vast expansion during the last century in recreation and industrial activities has placed diverse and increased pressures on estuarial waters. For better use of this part of our natural resources the dynamic behavior of estuaries must be understood. The most controversial subject in dealing with mass transport in estuaries is the relative magnitude of longitudinal versus transverse transport flow. This work is designed to clarify the controversy and to gain insights of the estuarial operating mechanism.

039-09091-410-44

NEARSHORE CIRCULATION, LITTORAL DRIFT AND THE SAND BUDGET OF FLORIDA

(*b*) Sea Grant, NOAA.

(*c*) A. J. Mehta and E. J. Hayter.
(*e*) To continue: 1) development of a Coastal Engineering Archives; 2) prepare glossary of inlets reports and work up data on inlets; 3) quantify inlet sand budgets and determine potential of inlet outer bars as a location for nourishment material for beach nourishment projects; 4) determine by a field study the rate and direction of littoral drift at Panama City, Florida; 5) to develop a pilot system capable of being used to determine littoral drift along Florida's shoreline and to check past analytically computed values of littoral drift; 6) to monitor and study beach nourishment projects to find out where sand placed on beaches is going, and to determine if presently developed analytical models of onshore/offshore and longshore sand movements are correct; 7) to support Marine Advisory Program.
The primary emphasis of this study is to identify and quantify beach erosion mechanisms and to implement these results into rational recommendations for beach erosion control. Additionally, a coastal engineering specialist has been added to the staff and provides a communications link with the users in coastal counties. Research results and advice for particular problems are conveyed to the user and also problem areas which may require research effort are identified.

039-09093-410-65

MONITORING OF FILL SOUTH OF CANAVERAL JETTIES

(*b*) Brevard County and Department of Natural Resources, and U.S. Army Corps of Engineers.
(*c*) J. A. Purpura.
(*e*) The beach south of Canaveral Harbor, Brevard County, was nourished with sand dredged from the Poseidon submarine base. A stretch of beach 2.2 miles long received 2.7 million cubic yards of selected sand. Artificial replenishment of eroded beaches by pumping sand is a method that is gaining more aceeptability and becoming a more viable and economically feasible method of protecting beaches in Florida. An understanding of the processes involved in sand movement is necessary and can be best achieved by closely monitoring restored beaches. The improved understanding will help not only in maintaining the restored beach, but also in planning for other restoration projects around the State of Florida.

039-09103-410-10

FIELD INVESTIGATIONS TO DETERMINE PERFORMANCE OF PONCE DE LEON IMPROVEMENT PLAN, FLORIDA

(*b*) U.S. Army Corps of Engineers.
(*c*) J. A. Purpura.
(*e*) Investigate through field measurements and tracings, the performance of a system of jetties, a jetty-weir and an impoundment basin recently constructed to stabilize the Ponce de Leon Tidal Inlet. The effect of this system on the adjacent coastline will be determined through careful monitoring. Baselines have been established. Field and aerial surveys revealed important and rapid coastline changes.

039-10442-410-60

COASTAL ENGINEERING FIELD STATIONS

(*b*) Legislative Appropriation.
(*c*) M. A. Latif, M. Smutz, A. R. Gondeck, S. L. Harrell, W. W. Howard and J. C. Lau.
(*e*) The field stations program is a continuing operation of the Coastal Engineering Laboratory and is directed toward establishing a number of stations on the coastlines of Florida. The purpose of the field stations is to measure the prevailing winds, waves and currents in the nearshore region. In addition, changes in beaches and offshore topography are obtained by periodic surveys. Analysis of the data provides reliable information on the wave climate and the correlation between wave energy and sediment movement of the specific sites. Knowledge of these factors is essential in any undertaking in the coastal zones, be it beach nourishment, inlet stability or offshore development. Equally important is the support provided by the field stations for projects that are funded from separate sources. The Marineland field station was the site last year of an extensive study involving 12 different national agencies conducting tests for the SEA-SAT ocean data satellite.

039-10443-410-60

COASTAL ENGINEERING STUDIES TO RECOMMEND COASTAL CONSTRUCTION SETBACK LINES FOR THE FLORIDA SHORELINES FRONTING ON THE ATLANTIC AND GULF COASTS

(*b*) Bureau of Beaches and Shores and Florida Department of Natural Resources.
(*c*) J. A. Purpura and T. Y. Chiu.
(*e*) To make the necessary technical investigations with the view of recommending construction setback lines for the various coastal counties of Florida. Investigations will include extensive field measurements and evaluation of historical data related to shoreline stability. Pertinent factors to be considered are elevations, vegetation-bluff line, wave uprush and existing structures.

039-10444-410-44

HURRICANE ELOISE–COASTAL DAMAGE AND SHORELINE CHANGES

(*b*) Sea Grant and Department of Natural Resources.
(*c*) J. A. Purpura, T. Y. Chiu, and B. D. Spangler.
(*e*) Hurricane Eloise, (September 1976) although a middle-range hurricane, was the worst storm to hit the Florida panhandle in 46 years. Due to accelerated haphazard development of Florida's coastline it was also the most physically destructive. The objective of the study is to record and analyze the effects of Eloise in regard to the following: Beach-dune offshore changes; destruction and damage to coastal structures and development and the recently established coastal construction setback line.

039-10445-410-13

LITTORAL DRIFT ESTIMATION BY IMPOUNDMENT USING SAND-BAG-GROIN AT PANAMA CITY, FLORIDA

(*b*) U.S. Corps of Engineers, Mobile, Alabama; Sea Grant and National Oceanic and Atmospheric Administration, and Florida Department of Natural Resources.
(*c*) Y. H. Wang and E. Partheniades.
(*e*) Vital information for designing a beach nourishment project is the volume and rate of sand movement in the littoral zone. This information may be obtained by intercepting and blocking the sand movement along the beach using a sand-bag-groin. The change of bathymetry on both sides of the groin is then monitored with the wave-energy input to the region to quantify the volume of drifting sand and the rate of transport.

039-10446-410-10

BEACH EROSION STUDY BY SAND TRACING AT SANTA ROSA ISLAND, FLORIDA

(*b*) U.S. Army Corps of Engineers.
(*c*) Y. H. Wang and T. H. Chang.
(*e*) Glittering white sand beaches at Santa Rosa Sound are eroding at an average rate of 3-5 feet per year. The purpose of this study is to determine where the sand is going and why. A sample of the local sand has been coated with a colored fluorescent dye and placed back on the beach. The sand movement is being correlated with physical environmental parameters such as wind and wave conditions.

039-10447-410-50

APPLICATION OF REMOTE SENSING TO COASTAL ENGINEERING PROBLEMS

(*b*) National Aeronautics and Space Administration.
(*c*) Y. H. Wang, A. J. Mehta, M. A. Latif and K. Brooks.

(*e*) This project is aimed at utlizing data collected by satellites and high-altitude airplanes in helping to solve coastal engineering problems. The coastal region of Clearwater Beach-Sand Key on the Gulf has been selected as the initial study area, since surface measurements of changes in beaches and the nearshore region would be made there periodically under separate projects. It is expected that correlation between the aerial data and surface observation will develop techniques for evaluating aerial data which will be applicable in other coastal regions also. At the study site itself, interpretation of the aerial data will provide a much more comprehensive understanding of the coastal processes, which would be used in solving the beach erosion-inlet stability problem at Clearwater.

039-10448-060-54

INTERFACIAL FRICTION COEFFICIENT FOR TWO-LAYERED STRATIFIED FLOW WITH SMALL RATES OF ENTRAINMENT

(*b*) National Science Foundation.
(*c*) E. Partheniades.
(*e*) A fundamental functional relationship between the interfacial friction coefficient and the pertinent gross-flow parameters in a two-layered stratified flow such as the one found in an estuary are investigated. Earlier experiments led to critical velocity as the controlling parameter for incipient entrainment and rates of entrainment. It seems, however, more likely that the interfacial shear stress should be a more representative flow parameter. The results will have direct and significant applicability to the evaluation of the salinity intrusion length in stratified and nearly stratified estuaries.

039-10449-410-00

THE HYDRODYNAMIC BEHAVIOR OF MATANZAS INLET AND VICINITY

(*b*) Engineering and Industrial Experiment Station and University of Florida.
(*c*) D. M. Sheppard and A. J. Mehta.
(*e*) Determining the hydrodynamics of the Matanzas Inlet-River-Intracoastal Waterway system. A specially designed data aquisition system is being developed for this purpose. The system which will be housed inside steel boxes suitable for installation in the field will operate in a continuous record mode or can be set to turn on periodically and record for a specified increment of time. The aquisition system will accept both digital or analog input signals from the transducers. Each unit will record four signals (such as magnitude and direction from two current meters). Cassette tapes will be used because of this availability and ease of handling in the field. These units will be used to measure tidal currents in the vicinity of Matanzas Inlet. The currents, together with data on tides and salinity variations will be used in the analysis of the hydrodynamics of the inlet system.

039-10450-410-10

MONITORING HYDROGRAPHIC PATTERNS AT MATANZAS INLET AND VICINITY

(*b*) U.S. Army Corps of Engineers.
(*c*) D. M. Sheppard, A. J. Mehta, E. J. Hayter, and D. R. Paul.
(*e*) Matanzas Inlet, located about 14 miles south of St. Augustine, Florida, connects the Atlantic Ocean to Matanzas River. In 1964, hurricane Dora caused a breakthrough across the land barrier separating the river from the Intracoastal Waterway. This breakthrough has steadily worsened the shoaling and navigation problem in the area. This project is concerned with monitoring the changes in the hydraulic regime which will result when the breakthrough is closed by the Corps of Engineers. Dynamic modeling of the flow system will allow prediction of the expected changes.

039-10451-730-00

A DYNAMIC MODEL OF AN OCEAN-INLET-BAY SYSTEM

(*c*) A. J. Mehta.
(*e*) This project involves the construction and calibration of a table-top plexiglass model of a tidal inlet for the purpose of demonstration to undergraduate students interested in Coastal Engineering. The model will enable students to understand the dynamics of the flow through the inlet as a result of tidal variation in the ocean on one side and the bay on the other side of the inlet, as well as freshwater outflow.

039-10452-410-50

INLET STABILITY STUDY BY REMOTE SENSING AT CLEARWATER, FLORIDA

(*b*) National Aeronautics and Space Administration.
(*c*) Y. H. Wang and M. L. Marco.
(*e*) Inlets around Florida's shoreline are vital for navigation and for the flushing of the bays and the intra-coastal waterways. Through inlets, the tidal fluctuations nourish the biological productive marshland. In particular, the behavior and stability of the Clearwater pass are intimately related to the well-being of this water-oriented community. This project is to utilize the earth satellite and U-2 flight imageries, and other old and new aerial photographs to study historical inlet boundary changes and shifting sand bars. These remotely sensed data are calibrated by ground truth measurements. Finally, the derived information will be used for improving and stabilizing the Clearwater Pass.

039-10453-410-65

CLEARWATER INLET HYDROGRAPHIC STUDY

(*b*) City of Clearwater.
(*c*) M. A. Latif and Y. H. Wang.
(*e*) Clearwater Inlet is located on the Gulf coast due west of Tampa, between Sand Key and Clearwater Beach. In order to stabilize the inlet, a 4000 ft-long rubble-mound jetty has recently been constructed on the south bank (Sand Key) of the inlet. The objective of this study is to evaluate the influence of the jetty on sand movement, navigational conditions, and stability of the neighboring beaches. The study will provide data to determine the need of a second jetty on the north bank and information needed to optimize a beach nourishment-channel dredging for the coastal region between Clearwater and Dunedin inlets.

039-10454-060-20

INSTABILITY OF INTERNAL WAVES

(*b*) Office of Naval Research.
(*c*) D. M. Sheppard and I. B. Chou.
(*e*) Mass density stratification is quite common in both the ocean and the atmosphere. Internal gravity waves often occur at the interface between the different density layers. The instability of these waves and the resulting turbulence plays an important role in the dispersion of nutrients, pollutants, salt, etc., in bays, estuaries, and the oceans. The purpose of this research is to provide, through both analytical and experimental studies a better understanding of the instability mechanism. The experiments are being conducted in the internal wave stratified flow facility in the Coastal Engineering Laboratory.

039-10455-060-20

STABILITY OF STRATIFIED SHEAR FLOW

(*b*) Office of Naval Research.
(*c*) D. M. Sheppard and G. M. Powell.
(*e*) Measurements in the ocean and the atmosphere have shown that the mass density stratification that occurs in these fluids is not gradually varying but rather is step-like in nature. The dispersion processes and even the shear flows themselves in these fluids is not well understood. This research is an attempt to shed light on this complicated flow problem through carefully performed experiments in a two-layer stratified shear flow.

039-10456-420-55

MEASUREMENT OF HURRICANE WAVES AND SURGE

(*b*) Nuclear Regulatory Commission.
(*c*) M. A. Latif and J. L. Hammack.
(*e*) A comprehensive program to measure waves and storm surge heights due to hurricanes has been initiated. A rugged, selfcontained unit to measure these parameters has been developed. Three or more sites on the Atlantic coast and possibly one site on the Gulf coast will be instrumented to obtain data on waves, surge and meteorological parameters. The data will aid in understanding the mechanism of storm surge and wave generation, and would also be used in verification of available theoretical models used for prediction of surge and waves.

039-10457-420-60

DIRECTIONAL WAVE ENERGY MEASUREMENT IN THE GULF OF MEXICO

(*b*) Florida Sea Grant.
(*c*) M. A. Latif and Y. H. Wang.
(*e*) One of the most important parameters in coastal engineering problems is the wave energy reaching the shore from various directions. The purpose of this project is to establish a directional wave gauge to measure this energy. The gauge consists of an array of pressure transducers, located just above the ocean floor in about 20 ft depth. Each pressure transducer senses the change in pressure due to passage of waves over it, and the directional energy is derived by correlating the measurements of the various transducers. The energy data can then be utilized to arrive at a more reliable value of littoral drift than that presently available. The gauge will be installed in the vicinity of the Clearwater Inlet, to aid in the solution of the beach and inlet stability problem at that site.

039-10458-430-20

FLOW FIELD NEAR AN OCEAN THERMAL ENERGY CONVERSION PLANT

(*b*) Office of Naval Research.
(*c*) D. M. Sheppard, G. M. Powell and I. B. Chou.
(*e*) Plants that utilize the difference in temperature between the upper and lower layers of the ocean to produce a more useful form of energy are presently being designed. Most all designs thus far include a large vertical pipe that extends from near the surface to a depth of 200 to 500 m. The thermally stratified flow field in the vicinity of these plants can be greatly affected by the presence of the pipe and the vast quantities of cold water being pumped from the lower depths and discharged in the upper layer. The purpose of the research is to determine the flow field near such a plant by studying a model in a stratified shear flow tank. Of primary concern is the wake region near the transition layer between the cold and warm layers. Salt stratification is used in the model to simulate the temperature stratification in the prototype.

039-10459-730-44

COASTAL ENGINEERING ARCHIVES

(*b*) Sea Grant and University of Florida.
(*c*) L. Lehmann.
(*e*) The Coastal Engineering Archives collects and organizes information about the physical processes (oceanography, geology, hurricanes, etc.) that affect the coast and beaches of Florida, with special emphasis on the causes and prevention of beach erosion. The materials acquired include technical reports, conference proceedings, maps, charts, and aerial photos. Information can be retrieved by geographic area and by subject. Reference service is available to students and researchers at the University of Florida and also to any interested persons or agencies inside the University.

GENERAL DYNAMICS CORPORATION, ELECTRIC BOAT DIVISION, Eastern Point Road, Groton, Conn. 06340. J. R. Hunter, Director of Engineering.

040-09846-210-00

PNEUMATIC AND HYDRAULIC TRANSIENTS IN SUBMARINE PIPING SYSTEMS

(*c*) Bernard S. Ryskiewich, Engineering Specialist, Systems Technology Department.
(*d*) Theoretical applied research.
(*e*) Two computer programs, HYTRN and PNUTRN, are under development to calculate unsteady flow transients in complex submarine piping systems containing assorted piping components. HYTRN applies to liquid systems while PNUTRN applies to gas systems and is presently coded for air and steam. The method of characteristics with fixed time steps is employed in each program. The programs are operational for systems containing systems components and boundary components presently available in their respective program libraries.
(*f*) Completion of the programs and their documentation is expected by the 1977 year end.

GENERAL ELECTRIC COMPANY, NUCLEAR ENERGY SYSTEMS DIVISION, 175 Curtner Avenue, San Jose, Calif. 95125. Mark F. Lyons, Manager, Engineering Applications.

041-07988-140-52

BLOWDOWN HEAT TRANSFER PROGRAM

(*b*) General Electric Company, Electric Power Research Institute, and Nuclear Regulatory Commission.
(*c*) G. W. Burnette, Mail Code 583.
(*d*) Experimental and theoretical, applied research.
(*e*) Program to provide data on transient heat transfer during conditions representative of a boiling water reactor undergoing hypothetical loss-of-coolant accident. Specific investigations include time to boiling transition, lower plenum swell hydrodynamics and core thermal response, and post-boiling transition and lower plenum swell heat transfer.
(*f*) Completed.
(*g*) A number of inherent cooling mechanisms were observed for which no credit is taken in the current BWR LOCA evaluation method. These cooling mechanisms consisted of (1) a fluid inventory which resided in the bundle throughout the blowdown and cooled the lower zone of the bundle, (2) steam updraft cooling in the upper zone by steam generated from flashing due to depressurization and heat transfer to the fluid inventory in the lower zone, and (3) rod rewetting during the lower plenum flashing surge and fallback of the fluid (deposited in the upper plenum during the lower plenum flashing surge) from the upper plenum.
These tests demonstrated the importance of various system design parameters as to their effect on the system thermal-hydraulic and bundle heat transfer response. For instance, variations in the break area and initial liquid mass in the annulus had a direct and significant effect on the system response and bundle heatup performance. Bundle power affected the bundle heatup response significantly, as expected, but did not affect the overall system response. Large variations in other parameters such as bypass flow area, lower plenum geometry, pump coastdown rate, and inlet subcooling had little effect on the system and bundle heatup responses.
The experimental results were further used to provide a basis for evaluating BDHT phenomena. Current BWR LOCA evaluation methods, when applied to the test apparatus, show a substantial margin in the prediction of peak cladding temperature. Observed thermal-hydraulic

and heat transfer phenomena were evaluated and compared with these methods. Specific phenomenologically based model improvements for break-flow and void distribution were recommended. Such improved thermal-hydraulic models are expected to provide more accurate and realistic predictions of the BWR system thermal-hydraulic blowdown responses.

(*h*) All documents listed may be obtained through Technical Information Center, P.O. Box 62, Oak Ridge, Tenn. 37830.

BWR Blowdown Heat Transfer Program, *Ninth Quarterly Progress Rept., GEAP-13317-09*, July 1-Sept. 30, 1974.

Determination of Transient Heat Transfer Coefficients and the Resultant Surface Heat Flux from Internal Temperature Measurements, R. J. Muzzy, J. H. Avila, D. E. Root, *GEAP-20731*, Jan. 1975.

BWR Blowdown Heat Transfer, *Tenth Quarterly Progress Rept., GEAP-13317-10*, Oct. 1-Dec. 31, 1974.

BWR Blowdown Heat Transfer, *Eleventh Quarterly Progress Rept., GEAP-13317-11*, Jan. 1-Mar. 31, 1975.

BWR Blowdown Heat Transfer, *Twelfth Quarterly Progress Rept., GEAP-13317-12*, Apr. 1-June 30, 1975.

BWR Blowdown Heat Transfer, *Thirteenth Quarterly Progress Rept., GEAP-13317-13*, July 1-Sept. 30, 1975.

BWR Blowdown Heat Transfer, *Fourteenth Quarterly Progress Rept., GEAP-13317-14*, Oct. 1-Dec. 31, 1975.

Blowdown Heat Transfer, W. A. Sutherland, *Review of Recent Results, GEAP-20936*, July 1975.

Blowdown Heat Transfer Phenomena in the Scaled BWR Test System, G. L. Sozzi, R. J. Muzzy, G. W. Burnette, *GEAP-21126*, Jan. 1976.

BWR Blowdown Heat Transfer Program, R. Muralidharan, et al., *Final Rept., GEAP-21214*, Feb. 1976.

Blowdown Heat Transfer Phenomena in the Scaled BWR Test System, G. L. Sozzi, R. J. Muzzy, G. W. Burnette, *ASME Paper 76-HT-7*, Aug. 1976.

041-09984-660-73

BLOWDOWN/EMERGENCY CORE COOLING PROGRAM

(*b*) General Electric Company, Electric Power Research Institute, and Nuclear Regulatory Commission.

(*c*) G. W. Burnette, Project Manager, Mail Code 583.

(*d*) Experimental and theoretical; applied research.

(*e*) Program will obtain and evaluate basic BWR blowdown/ECC injection thermal-hydraulic and heat transfer data from test system configurations which have performance characteristics similar to a BWR during a hypothetical Loss-of-Coolant-Accident (LOCA). The second principal objective is to determine the degree to which current LOCA models describe the observed phenomena, and as necessary, develop improved models. A scaled BWR reactor system simulator called the Two Loop Test Apparatus (TLTA) will be used to provide the LOCA test conditions representative of the environment characteristic of a contemporary BWR under postulated LOCA conditions. The scaling and design objectives for the TLTA are to provide a system test apparatus for investigating, on a real time basis, the expected BWR fuel thermal-hydraulic response using an electrically heated, full size, full-power test bundle. In addition to establishing the reference performance, system parameters will be varied including break area and location, ECC and BWR configurations as they vary between BWR models, and bundle power variations. ECC parameters include flow rates, subcooling, injection location, injection mode, time of injection, and ECC system sequencing.

(*g*) The Preliminary Program Plan has been developed which shows how the program objectives are to be met using a phased approach to testing. An analysis of electrically heated rods has been completed showing that such rods can be power programmed to simulate nuclear fuel rods during a LOCA. A test plan has been developed for the first phase of testing which is now underway and results of these tests indicate that peak clad temperatures in the 8 ×8 rod bundle simulator (< 1100 °F) are several hundred degrees lower during the blowdown period than those measured in a 7×7 rod bundle. A transient thermal hydraulic method has been developed which can be used to calculate local thermal hydraulic conditions in rod bundles during BWR blowdown conditions. The method is based on a drift flux model. Conditions of cocurrent upflow and counter current flow can be analyzed and counter-current flow limiting at the top of the bundle can also be accommodated. Heat conduction in the fuel or heater rods can be calculated or heat flux to the fluid can be specified as a boundary condition.

(*h*) All documents listed may be obtained through Technical Information Center, P.O. Box 62, Oak Ridge, Tenn. 37830.

BWR 8×8 Fuel Rod Simulation Using Electrical Heaters, J. P. Dougherty, R. J. Muzzy, *GEAP-21207*, Mar. 1976.

BWR Blowdown/Emergency Core Cooling, *First Quarterly Progress Rept., GEAP-21304-1*, Jan. 1-Mar. 31, 1976.

Preliminary BWR Blowdown/Emergency Core Cooling Program Plan, R. J. Muzzy, *GEAP-21255*, June 1976.

BWR Blowdown/Emergency Core Cooling, *Second Quarterly Progress Rept., GEAP-21304-2*, Apr. 1-June 30, 1976.

64-Rod Bundle BDHT Test Plan, J. P. Walker, *GEAP-21333*, Sept. 1976.

BWR Blowdown/Emergency Core Cooling, *Third Quarterly Progress Rept., GEAP-21304-3*, July 1-Sept. 30, 1976.

BWR Blowdown/Emergency Core Cooling, *Fourth Quarterly Progress Rept., GEAP-21304-4*, Jan. 1-Mar. 31, 1977.

MAYU04–A Method to Evaluate Transient Thermal Hydraulic Conditions in Rod Bundles, W. C. Punches, *GEAP-23517*, (to be published).

041-09985-660-52

FLOW-INDUCED VIBRATION FOR LIGHT WATER REACTORS

(*b*) U.S. Energy Research and Development Administration.

(*c*) J. F. Schardt, Project Manager, FIV for LWR Program, Mail Code 589.

(*d*) Experimental, theoretical, and field investigation; applied research and development.

(*e*) Increase light water reactor availability through development of improved flow-induced vibration design criteria, analytical methods, and general scaling laws. Fundamental studies related to cross and parallel flow over tube banks, leakage flow mechanisms, and random vibration effects will be performed by General Electric's Research and Development Center and Argonne National Laboratory. In conjunction, studies on scale model and prototype boiling water reactor components will be performed by General Electric's Nuclear Energy Systems Division. Results from the fundamental and reactor component studies will be utilized as input for design methods, guides, and criteria development. Design methods will be verified through comparison with reactor field data.

GENERAL ELECTRIC COMPANY, RE-ENTRY AND ENVIRONMENTAL SYSTEMS DIVISION, P.O. Box 8518, Philadelphia, Pa. 19101. Dr. Ralph R. Boericke, Manager, Advanced Environmental Technology Laboratory.

042-08677-440-44

LAKE ONTARIO ICE MODELING

(*b*) Great Lakes Environmental Research Laboratory (NOAA) as part of the International Field Year on the Great Lakes (IFYGL).

(*c*) J. F. Dilley, Research Engineer.

(*d*) First year, experimental; second and third years, analytical; basic research.

(*e*) Ice formation growth and decay on Lake Ontario was simulated on two scales; a small, local, near shore scale and a whole lake scale. Each surface heat transfer mode is

computed separately so that its importance can be quantitatively evaluated. The whole lake ice computations were performed to supply an input for latent heat of fusion into the energy budget being compiled by the IFYGL energy budget panel.
(*f*) Completed.
(*g*) It was found that the convective flux dominated the heat loss during freezing periods and that it was usually twice as large as the evaporation loss. The solar flux usually dominated during the melting periods. The near shore ice thicknesses compared very well with the closest available ice thickness data. The whole lake model generated realistic ice distributions when compared with ice charts and satellite images. The computed net heat loss for the winter was lower than the data indicated due to under-estimating the eddy diffusivities which are very high during the winter.
(*h*) **Lake Ontario Ice Modeling–IFYGL Phase 3 Final Report,** J. F. Dilley, *GE/RESD Rept. No. 76SDR2209*, June 1976 (available Great Lakes Environmental Research Lab., Ann Arbor, Mich. 48104).

042-08679-400-73

ESTUARINE HYDRAULICS AND THERMAL DISPERSION

(*b*) Consolidated Edison Co. of New York, Inc.
(*c*) Dr. R. R. Boericke; Manager, Advanced Environmental Technology Laboratory.
(*d*) Theoretical, applied research.
(*e*) Develop and validate two-dimensional time-dependent numerical models for the prediction of hydraulics and thermal dispersion in estuaries. The three-dimensional (XYZ) solution is approximated by separate simulations in the XZ and XY planes. The solution in the XZ plane is obtained by numerically integrating the continuity, momentum, and energy equations on a computational grid spanning the longitudinal (X) and vertical (Z) directions. The XY model provides the solution to these equations in the longitudinal (X) and lateral (Y) directions. The two models are coupled together to provide definition of the three-dimensional temperature distribution throughout the tidal cycle. The XZ model formulation includes the pressure gradient terms arising from longitudinal salinity variations, and can therefore predict salinity-induced circulation patterns.
(*g*) Computer models have been validated by comparisons with field data. Further comparisons are in progress.
(*h*) **An X-Z Hydraulic/Thermal Model for Estuaries,** R. R. Boericke, J. M. Hogan, *J. Hyd. Div., Proc. ASCE* **103**, HY1, pp. 19-37, Jan. 1977.

042-10560-510-00

STATIC STABILITY OF CAVITATING, UNDERWATER VEHICLE WITH GAS INJECTION AT THE BASE

(*c*) Dr. R. R. Boericke, Manager, Advanced Environmental Technology Laboratory.
(*d*) Experimental, applied research.
(*e*) A series of high-speed towing tank tests are planned to evaluate the static stability of a slender underwater vehicle with a large volume flow rate of gas injected from the base at various (small) angles from the axial direction. Vaporous cavitation will be encountered in the lower portion of the cavitation number range which will span 0.3 to 0.8. Gas scaling is used to match, 1) the exit to ambient pressure ratio, 2) the exhaust gas volume flow rate coefficient, and 3) the exhaust gas momentum ratio.
(*g*) Computer analysis has indicated that gas injection at the base changes both moment and normal force derivatives in the destabilizing direction.

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THE GEORGE WASHINGTON UNIVERSITY, Department of Civil, Mechanical, and Environmental Engineering, Washington, D.C. 20052. Dr. S. W. Yuan, Department Chairman.

043-10345-300-54

RIVER MECHANICS

(*b*) National Science Foundation.
(*c*) Professor K. Mahmood.
(*d*) Field research.
(*e*) Field research is conducted on large sand bed link canals in Pakistan to study the hydraulic, sedimentation and morphologic aspects of alluvial channels under steady and unsteady flow conditions.
(*g*) Field research organization has been set up. Research is under way on a number of problems based on specially designed research experiments. Three broad categories of research have been developed: 1) Baseline experiments for the study of long term behavior of alluvial channels; 2) Equilibrium experiments for the study of quasi-equilibrium conditions; and 3) Special experiments relating to the study of mechanics of alluvial channels under equilibrium, nonequilibrium and unsteady flow conditions.
(*h*) **Field Research in Large Sand Bed Channels,** K. Mahmood, R. N. Tarar, *RIVERS 76, Proc. 3rd Ann. Symp. Inland Waterways for Navigation, Flood Control and Water Diversions, ASCE*, 1976.

043-10346-220-54

SEDIMENT SUSPENSION IN DEVELOPING FLOWS

(*b*) National Science Foundation.
(*c*) Professor K. Mahmood.
(*d*) Basic research.
(*e*) A numerical solution has been developed to simulate the momentum and mass transfer in developing turbulent flows. This solution is useful in predicting the velocity and sediment concentration distribution in the developing regions of sand bed channels. Verification of the model from field data is in progress.
(*g*) **Mathematical Modeling of Sediment Diffusion in Developing Flows,** K. Mahmood, H. A. Karvigh, to be published in *Proc. XVIIth Congress, Intl. Assoc. Hydraulic Research*, Baden-Baden, Germany, 1977.

043-10347-220-54

BED FORMS IN SAND BED CHANNELS

(*b*) National Science Foundation.
(*c*) Professor K. Mahmood.
(*d*) Basic research.
(*e*) The behavior of alluvial channels such as the resistance to flow is intimately related to its bed forms. It is not commonly recognized that bed forms, such as point bars in otherwise straight channels can also contribute to lateral instability of channels. Similarly long bed waves, representing sedimentation transients, can locally reduce flow depth and channel discharge capacity. The purpose of this study is to develop models for the prediction of bed form development and their fate in sand bed channels. The models are then to be tested for data obtained from field research.
(*h*) **Mathematical Modeling of Morphological Transients in Sandbed Canals,** K. Mahmood, *Paper No. B8, Proc. XVIth Congress, Intl. Assoc. for Hydraulic Research*, Sao Paulo, Brazil, 1975.
Analysis of Bed Profiles in Sand Bed Canals, K. Mahmood, H. A. Karvigh, *RIVERS* **76,** *Proc. 3rd Ann. Symp. Inland Waterways for Navigation, Flood Control and Water Diversions, ASCE*, 1976.
Meandering Talwegs in Straight Alluvial Channels, K. Mahmood, V. M. Ponce, *RIVERS* **76,** *Proc. 3rd Ann. Symp. Inland Waterways for Navigation, Flood Control and Water Diversions, ASCE*, 1976.
Mathematical Modeling of Sedimentation Transients in Sand Bed Channels, K. Mahmood, V. M. Ponce, *Tech. Rept. No. CER 75-76 KM-VMP 28*, Colorado State University, 1976.

Statistical Procedures for Bed Form Analysis, K. Mahmood, H. A. Karvigh, *Tech. Rept. No. CER 75-76 KM-HAK 41*, Colorado State University, 1976.

043-10348-220-54

SEDIMENT CONCENTRATION PROFILES

(*b*) National Science Foundation.
(*c*) Professor K. Mahmood.
(*d*) Basic research.
(*e*) Distribution of sediment concentration along the depth of an alluvial channel is an important factor in determining the sediment load. A reliable quantitative predictive method is not presently available. Theoretical research is under way to develop it.
(*g*) As a part of data collection effort, a pumping sampler has been developed. This is being used to sample long time average sediment concentrations at various points in the depth of flow.
(*h*) **ACOP Pumping Sampler,** K. Mahmood, G. L. Eyster, Alluvial River Mechanics Project, Colorado State Univ., Fort Collins, *Colo. Rept. No. CER 74-75 KM-GLE*, Mar. 1975.
Variation of Suspended Sediment in Sand Bed Canals, K. Mahmood, G. L. Eyster, *RIVERS* **76,** *Proc. 3rd Ann. Symp. on Inland Waterways for Navigation, Flood Control and Water Diversions, ASCE*, 1976.

043-10349-220-54

SEDIMENT DIVERSION STRUCTURES

(*b*) National Science Foundation.
(*c*) Professor K. Mahmood.
(*d*) Basic research.
(*e*) Sediment diversion and control structures are used as an integral part of water conveyance and delivery system to maintain sediment discharge equilibrium. Theoretical studies are conducted to develop models for the water and sediment conduction through these structures. A model for vortex tube sand trap is now being used to develop designs for increasing the sediment removal efficiencies.
(*g*) Results of analytic model have been verified on laboratory data. They show that the flow entrance to the tube is not uniform. The efficiency of the tube is thereby reduced.
(*h*) **Flow Through Vortex Tube Sediment Ejectors,** K. Mahmood, *Proc. ASCE Irrigation and Drainage Specialty Conf.*, Logan, Utah, 1975.
Modeling Sediment Transport in Hydraulic Structures, K. Mahmood, *Proc. MODELING* **75,** *2nd Ann. Symp. Modeling Techniques for Waterways, Harbors and Coastal Engrg.*, San Francisco, Calif., Sept. 3-5, 1975.

043-10350-300-54

ERROR MODELS FOR ALLUVIAL CHANNEL MEASUREMENTS

(*b*) National Science Foundation.
(*c*) Professor K. Mahmood.
(*d*) Basic research.
(*e*) To verify theories of alluvial channel behavior it is necessary to test these against empirical data. This process requires an error model of the measurements of various quantities, so that statistical tests can be applied. Error models also help identify quantities that need to be more accurately measured in the context of analyses for which they are sampled.
(*g*) Error models have been developed for the channel cross sectional area, discharge, velocity distribution and sediment load. Errors have been classified as random, consistent and procedural. The procedural errors relate to the manner in which the basic measurements are obtained and reduced to calculate derived quantities. Given the magnitude of errors in basic measurements, recommendations have been developed to decide the number of spatial samples. Field investigations on the magnitude of random errors in basic measurements are presently continuing.
(*h*) **Procedural Errors in Alluvial Channel Measurements,** K. Mahmood, T. Masoud, M. M. Siddiqui, *RIVERS* **76,** *Proc. 3rd Ann. Symp. on Inland Waterways for Navigation, Flood Control and Water Diversions, ASCE*, 1976.

043-10351-050-54

ENERGY SEPARATION

(*b*) National Science Foundation.
(*c*) Professor J. V. Foa.
(*d*) Theoretical basic research, for Doctoral theses.
(*e*) The process under study utilizes the fact that when a two-dimensional jet impinging onto a wall is imparted a transverse motion, the two branches into which the jet divides on impingement emerge at different energy levels. The research examines the effects of viscous entrainment and of other factors affecting the process and assesses the potential merit of energy separation in air-cycle and vapor-compression applications.
(*g*) A methodology has been developed for the analysis of viscous effects in the impingement of a jet on a moving wall; comparative evaluations have been made of the performance of air-cycle device with and without energy separation.
(*h*) **Air Cycles with Energy Separation,** J. V. Foa, *Ferrari Tribute Volume*, Levrotto and Bella, Turin, pp. 239-254, Dec. 1974.
A Comparative Study of Air-Cycle Systems for Home Air Conditioning, D. R. Sobel, *GWU Report TR-ES-761*, Feb. 1976.

043-10352-550-22

UNDERWATER THRUST AUGMENTATION

(*b*) Naval Sea Systems Command and Naval Air Systems Command.
(*c*) Professor J. V. Foa.
(*d*) Applied research, mostly theoretical, for Doctoral theses.
(*e*) The research concerns the flow transformations which take place in underwater thrust augmenters of three classes–ejectors, underwater ramjets, and axial-flow cryptosteady interaction devices ("rotary jets")–with particular attention to the latter class.
(*g*) General performance equations, covering all three classes, have been developed. Also, much progress has been made in the analysis of the flow induction mechanism of the rotary jet by a new approach, which accounts for the cross-sectional shape of the rotor discharge nozzles and for the gradualness of the interpenetration of the interacting flows.
(*h*) **Steady- and Cryptosteady-Flow Underwater Thrust Augmentation–Part I-Governing Equations,** J. V. Foa, *GWU Report TR-UTA-751*, Nov. 1975.
Steady- and Cryptosteady-Flow Underwater Thrust Augmentation–Part II-Numerical Results, T. Costopoulos, *GWU Report TR-UTA-762*, Dec. 1976.
Ejectors and Rotary Jets as Thrust Augmenters, J. V. Foa, *Marine Propulsion, ASME-OED Publication*, pp. 13-21, Dec. 1976.
A Wide-Jet Strip Analysis of Cryptosteady-Flow Thrust Augmenters, T. Costopoulos, *GWU Reports TR-UTA-771 and 772*, Mar. 1977.

043-10353-550-00

REDUCTION OF ENERGY CONSUMPTION IN TRANSPORTATION

(*c*) Professor J. V. Foa.
(*d*) Theoretical, applied research for Master's thesis.
(*e*) Study deals with a mechanism combining boundary layer control with the utilization of boundary layer air for the generation of thrust.
(*g*) The feasibility and potential advantage of this method of drag reduction and propulsion have so far been found to be far greater in land or sea than in air transportation.
(*h*) **Reduction of Energy Consumption in High-Speed Ground Transportation,** *High-Speed Ground Transportation Journal* **9,** 3, Fall 1975.

GEORGIA INSTITUTE OF TECHNOLOGY, School of Civil Engineering, Atlanta, Ga. 30332. Paul H. Sanders, Assistant Director.

044-06693-070-00

SOLUTIONS OF SEEPAGE THROUGH COMPLEX MEDIA BY FINITE ELEMENTS

(*c*) Dr. P. G. Mayer.
(*d*) Theoretical; basic research.
(*e*) Seepage through naturally occurring materials frequently requires treatment of media which are seldom isotropic and more often nonhomogeneous. The method of finite elements is a general numerical method by which complicated seepage problems can be effectively conditioned for digital computation.
(*h*) **Application of Finite Element Analysis in Fluid Mechanics,** M. M. Aral, *Ph.D. Thesis*, Ga. Inst. of Tech., 121 pages, Sept. 1971.
Finite Element Galerkin Method Solutions to Selected Elliptic and Parbolic Differential Equations, (with M. Aral, C. V. Smith, Jr.), *Proc. Air Force 3rd Conf. Matrix Methods in Structural Mechanics*, 31 pages, Oct. 21, 1971.
The Fate of Radionuclides in Groundwater Environment, (with C. V. Smith), *Proc. Intl. Symp. on Finite Element Methods in Flow Problems*, Swansea, Great Britain, pp. 541-544, Jan. 7-11, 1974.
Finite Element Solutions of Selected Partial Differential Equations–Femac Computer Program, M. Aral, Middle East Tech. Univ., 99 pages. 1974.
Solute Transport in Groundwater, H. Kleinsorge, *M.S. Report*, Ga. Inst. of Tech., 82 pages, Aug. 1975.

044-06695-250-61

UNSTEADY FLOW OF DILUTE AQUEOUS HIGH POLYMER SOLUTIONS IN PIPES

(*b*) Water Resources Center.
(*c*) Dr. P. G. Mayer.
(*d*) Theoretical and experimental; basic research.
(*e*) Small traces of certain long-chain polymeric molecules, dissolved in water, reduce turbulent friction in flow through pipes. Local additions of polymers will change the resistance characteristics almost instantly, and the progress of the fluid slug with changed properties is a time dependent process. A mathematical study of head and velocity changes is to be carried out using numerical procedures and an electronic digital computer. The mathematical problem is to be formulated as an initial value problem. Solutions to simple pipe problems involve the Runge-Kutta procedures and the Adams-Bashforth method. A laboratory study of unsteady pipe flow is to verify the mathematical model. The mathematical procedures are to be extended to parallel pipe systems and to pipe networks.
(*g*) Experiments carried out in a 2-inch diameter pipe demonstrated that a 40 percent reduction resulted from admixture of 100 parts per million by weight. Reductions as much as 60 percent were observed at polymer concentrations of 300 parts per million. The experiments were carried out as steady-state processes. The basic simple pipe unsteady flow problem has been solved numerically. Laboratory experiments are under way to verify the procedures.
(*f*) Complete.
(*h*) **Unsteady Flow of Aqueous Solution of Long-Chain Polymers in Pipe Networks,** H. C. Jackson, *M.S. Thesis*, Ga. Inst. Tech., Jan. 1970, 135 pages.
Unsteady Flow of Dilute Aqueous Polymer Solutions in Pipe Networks–A Method to Improve Water Distribution, *WRC Rept. 0170*, Water Resour. Ctr., Ga. Inst. Tech., Feb. 1970, 139 pages.

044-06699-430-00

DYNAMIC RESPONSE FUNCTIONS OF OCEAN STRUCTURES

(*c*) Dr. P. G. Mayer.
(*d*) Theoretical; Ph.D. thesis.
(*e*) Develop a technique for analyzing the dynamic response of off-shore structures subjected to random wave forces and to the constraints imposed by the foundation medium of the ocean floor. Emphasis is placed on the use of existing models of the forcing functions and the restraining functions to formulate a numerical method analysis. The structural model is analyzed for free and random vibrations. Cross-power spectra are developed for random force fields and random wave heights. Consideration is given to fluid damping and the effects of vortex shedding. Dynamic resistance of soils to the movements of piles is to be included. The finite element method may be used in the analysis of dynamic foundation response.
(*f*) Complete.
(*h*) **Dynamic Structure-Soil-Wave Model for Deep Water,** *J. Waterways, Harbors and Coastal Engrg. Div., ASCE*, Paper No. 7889, Feb. 1971, pp. 107-184.
An Analysis Technique for Composite Structures Subject to Dynamic Loads, *Trans. ASME* **38**, Series E, 1, Mar. 1971, pp. 118-124.

044-07300-220-00

TRANSPORT CHARACTERISTICS OF LOG-NORMAL DISTRIBUTED BED MATERIALS IN OPEN CHANNELS

(*c*) Dr. P. G. Mayer.
(*d*) Theoretical and experimental; Ph.D. thesis.
(*e*) Information is sought on the interaction of the turbulence structure in open channel flow and the bed load movement of log-normally distributed bed materials. Time-dependent measurements are made of sediment transport and size distributions. Turbulence measurements are made with a constant temperature hot-film anemometer. The phenomenon of armoring is investigated.
(*h*) **An Experimental Study of Bed Armoring,** *Proc. Einstein Sediment Symp.*, Univ. Calif., Berkeley, June 1971.
The Role of Sediment Gradation on Channel Armoring, W. C. Little, *Ph.D. Thesis*, Ga. Inst. of Tech., May 1972, 104 pages.
The Role of Sediment Gradation on Channel Armoring, *ERC-0672*, Ga. Inst. of Tech., May 1972, 104 pages (with W. C. Little).
Stability of Channel Beds by Armoring, *J. Hydr. Div., ASCE*, pp. 1647-1661, Nov. 1976 (with W.C. Little).

044-08010-350-73

EFFECT OF PIER SHAPES AND PIER LOCATIONS ON SPILLWAY CAPACITIES

(*b*) Georgia Power Company.
(*c*) Dr. P. G. Mayer.
(*d*) Applied research.
(*e*) Laboratory studies are conducted to obtain design criteria. 1:100 and 1:60 hydraulic models are tested.
(*f*) Completed.
(*g*) The tests made in order to establish the capacity of the spillway for the Wallace Dam Project were carried out on a 1:60 scale partial model. The test results showed conclusively that the most probable flood of some 307,000 cfs can be accommodated with the reservoir surface elevation at 440 feet MSL. The accommodation of the most probable flood over the spillway requires that the crest control Tainter gates be completely open. The entrance to the spillway was modeled with two different abutment configurations at the powerhouse. One was a quarter-circular abutment, the other was a semi-circular pier extension into the reservoir. The quarter-circular abutment resulted in flow separation at the powerhouse wall and in unsteady flows which would also result in pressure fluctuations on the powerhouse wall. The semicircular pier extension allowed the flow to remain attached, and both the flow separation and the expected pressure fluctuations were thus eliminated. In order to establish the effectiveness of the energy dissipator, a series of tests were carried out. The variables included the range of flows, the radius of a flip bucket, the invert elevations of the bucket, the exit

angle, and the geometry of the wingwall between the spillway and the tailrace of the powerhouse. An optimum combination of the variables resulted when the flip bucket had a 60-foot radius, an exit angle of 25 degrees, a bucket invert elevation of 333 feet, and when the wingwall was at an elevation of 335 feet.

(*h*) **Vortex Phenomena at Hydraulic Intake Structures,** presented at *ASCE, Water Resources Mtg.*, Los Angeles, Calif., Jan. 21-25, 1974.
Near-Field Jet Penetration and Reservoir Mixing, *ASCE Symp. Modeling Techniques*, pp. 380-387, Sept. 1975.

044-08011-340-73

RESERVOIR CIRCULATION IN A PUMPED-STORAGE PROJECT

(*b*) Georgia Power Company.
(*c*) Dr. P. G. Mayer.
(*d*) Theoretical, applied research.
(*e*) A 30 x 50 foot laboratory model was built on a distorted scale (1:400 horizontal, 1:60 vertical). Studies being conducted to establish near-field and far-field circulation patterns. The project is designed to provide design information for the Wallace Dam Pumped-Storage Project of the Georgia Power Company.

044-08012-360-73

CROSS-FLOW ASSISTED HYDRAULIC JUMPS

(*b*) Georgia Power Company.
(*c*) Dr. P. G. Mayer.
(*d*) Theoretical and applied research.
(*e*) Cross-flow assisted hydraulic jumps form at conjugate depths less than those predicted by two-dimensional momentum analysis. The studies are intended to explain the phenomena and to establish design criteria.
(*f*) Complete.

044-08013-350-00

SPILLWAY CREST PRESSURES AT PARTIALLY OPEN TAINTER GATES

(*c*) Dr. P. G. Mayer.
(*d*) Theoretical and applied; M.S. thesis.
(*e*) Dam spillway standard crest shapes are often designed for about 75 percent of the design head in order to obtain greater discharge capacity. This procedure results in negative pressures which have been measured. The addition of Tainter gates as crest control structures provides for the opportunity to discharge from partially open gates. The jet trajectory from the partially open Tainter gates is different from that used for the design of the standard overflow spillways. The study is intended to delineate the limiting condition which would prevent the occurrence of cavitation and cavitation damage.
(*f*) Complete.

044-08814-210-54

EFFECT OF ENTRAINED AIR ON PRESSURE TRANSIENTS

(*b*) National Science Foundation.
(*c*) Dr. C. S. Martin.
(*d*) Experimental and analytical; Doctoral research.
(*e*) A three-year research effort has been completed on the investigation of the effect of gases, free and dissolved, on pressure transient phenomena in pipelines. As gases may be present in the dissolved and/or in the entrained state in cooling water systems of thermal power stations, in sewage pumping lines, or in crude oil lines, the effect of the compressibility of any entrained gas on the wave propagation speed, and on any resulting pressure transient, must be ascertained to perform a proper analysis. In addition to problems concerning the prediction of pressure changes in dispersed mixtures in pipelines for which flow changes occur due to valve operation or machine behavior, the effect of entrained gas on resonating frequencies may likewise be important. An experimental apparatus was built to produce a steady flow of an air-water mixture in a plexiglass pipeline. By means of valve operation, sudden, gradual, or oscillating, the pressure transients were produced. For sharp pressure changes the wave propagation speed and amplitude variation along the pipeline was determined. The dissipative and dispersive nature of the mixture as well as the formation of shocks will be ascertained.
(*f*) Completed.
(*h*) **The Effect of Free Gases on Pressure Transients,** C. S. Martin, M. Padmanabhan, *L'Energia Elettrica* **52,** 5, pp. 262-267, May 1975.
The Effect of Free Gases on Pressure Transients, C. S. Martin, M. Padmanabhan, *Final Report, NSF Grant GK-38570*, Ga. Inst. Tech., June 1976, 209 pages.
Pressure Wave Propagation in Two-Phase Bubbly Air-Water Mixtures, C. S. Martin, M. Padmanabhan, D. C. Wiggert, *2nd Intl. Conf. Pressure Surges*, The City University London, Paper C1, Sept. 1976.

044-08815-040-00

EFFLUX FROM A DOUBLE-OPENING SLOT

(*c*) Dr. C. S. Martin.
(*d*) Theoretical.
(*e*) Irrotational flow of two-dimensional jets from a channel is treated without the direct use of a logarithmic hodograph plane. An analytical approach is introduced for solving the general problem of two jets issuing from a channel with three end plates. Numerical values of the contraction coefficient and the angle of jet deflection are obtained for the special case of the two jets symmetrically located and all end plates in line. Limiting cases of the resulting single-jet problem are the symmetric and unsymmetric configurations solved by von Mises. Results for the unsymmetric case improve upon the theoretical values reported by von Mises, and compare favorably with existing experimental data.
(*f*) Completed.
(*h*) **Asymmetric Two-Dimensional Jet Efflux from a Channel,** C. S. Martin, *J. Fluid Mechanics* **80,** pp. 1-15, 1977.

044-08816-030-00

PERIODIC MOTION OF A ROLLING SPHERE ON A BOUNDARY

(*c*) Dr. C. S. Martin.
(*d*) Experimental.
(*e*) The rolling motion of a sphere on a smooth plane boundary in a simple-harmonic water motion has been analytically and experimentally investigated. For spheres having specific gravities ranging from 0.09 to 15.18 the sphere motion was found to be sinusoidal for both low and high values of the period parameter defined by Keulegan and Carpenter. The knowledge of the sphere motion, and hence the resultant force, allowed the determination of inertia and drag coefficients from Fourier-averaging techniques. Experiments in the inertial range yielded an added-mass coefficient of 1.2, compared with 0.67 from inviscid theory for translating spheres. For values of the period parameter greater than 30 the drag coefficient is reported to be approximately 0.74.
(*f*) Completed.
(*h*) **Rolling Motion of a Sphere on a Plane Boundary in Oscillatory Flow,** C. S. Martin, M. Padmanabhan, C. D. Ponce-Campos, *Fluid Mechanics* **76,** 4, pp. 653-674, 1976.

044-09954-130-00

VERTICALLY DOWNWARD TWO-PHASE FLOW

(*c*) Dr. C. S. Martin.
(*d*) Experimental.
(*e*) Vertically downward two-phase flow of air-water mixtures has been investigated in circular pipes of diameter, 2.60 cm, 10.16 cm, and 14.00 cm. Bubbly flow, transition from bubbly flow to slug flow, and slug flow have been the principal flow regimes under investigation. For bubbly flow the measured pressure gradient is correlated with the mass

flow rates and the local cross-sectional average void fraction. Based upon visual observation, void fraction oscillations, and pressure fluctuation measurements, transition from bubbly flow to slug flow was found to occur for void fractions greater than approximately 0.20. The terminal velocity of descending, stationary, and ascending bubbles in downward slug flow was measured and correlated with the air and water volumetric flow rates. Except for very small pipe diameters, bubbles in downward slug flow are unstable and eccentrically located off the pipe axis in regions of lower fluid velocities. Consequently the drift velocity is higher for downward flows than for upward flow.

(*h*) **Vertically Downward Two-Phase Slug Flow,** C. S. Martin, *J. Fluids Engrg., ASME* **98,** pp. 715-722, 1976.

044-09955-030-00

OSCILLATORY FLOW OVER A FLAT PLATE

(*c*) Dr. C. S. Martin.
(*d*) Experimental.
(*e*) The oscillatory flow of water over a flat plate normal to a plane boundary has been investigated in a large U-tube. By means of a feedback-controlled air-pressure forcing system steady-state water particle displacements up to 1.5 ft can be generated in the 4 ft wide by 10 ft long by 1 ft deep test section in which the plates of heights 2, 4, and 6 inches were mounted. Energy dissipation in the entire system is determined by measuring the work input by the air pressure. Fluid resistance to the plate is calculated by applying Fourier-averaging techniques to the difference in work input with and without the plate. Drag coefficients based upon energy dissipation measurements show that, in contrast to steady flow results, there is no blockage effect. In future work the force on the plate will be directly measured.
(*h*) **Fluid Resistance to Oscillatory Flow Over A Flat Plate Normal to a Plane Boundary,** C. S. Martin, J. C. Bausano, *2nd Ann. ASCE EMD Specialty Conf.*, May 23-25, 1977.

044-09956-350-75

HYDRAULIC MODEL STUDIES–BATH COUNTY SPILLWAY

(*b*) Harza Engineering Company and Virginia Electric and Power Company.
(*c*) Dr. C. S. Martin.
(*d*) Experimental.
(*e*) A 60:1 scale model was constructed of a portion of the upper reservoir, the chute spillway and stilling basin, and the downstream erodible tailrace channel. Erosion in the tailrace channel was determined for several stilling basin designs and for a range of discharges and tailwater conditions in order to arrive at a final design. Flow conditions in the spillway approach channel were observed. Piezometric-pressure and water-surface profiles along the spillway crest and chute were measured for several flows. By means of pressure transducers, pressure fluctuations were measured at twenty locations in the stilling basin; namely, on the baffle blocks, on the end sill and on the walls and floor of the stilling basin.
(*f*) Completed.
(*h*) **Hydraulic Model Studies–Bath County Spillway,** C. S. Martin, M. Padmanabhan, *Final Rept.*, Ga. Inst. of Technology, June 1977.

044-09957-340-75

RIVER WATER INTAKE HYDRAULIC MODEL

(*b*) EBASCO SERVICES and Dayton Power and Light Company.
(*c*) Dr. C. S. Martin.
(*d*) Experimental.
(*e*) A 6:1 scale model was constructed of a 26-ft diameter caisson pump intake structure. The purpose of the model was the determination of submergence depths, clear depths, and pump separation. Various modes of operation of two intake pipes and six pumps were investigated for the purpose of studying the possibility of vortex formation.
(*f*) Completed.

HARVARD UNIVERSITY, Department of Engineering and Applied Mathematics, Cambridge, Mass. 02138. Professor Myron B. Fiering.

045-10112-880-54

MANAGEMENT AND STANDARDS FOR ECOSYSTEMS

(*b*) National Science Foundation.
(*d*) Theoretical, applied, one Doctoral thesis derived.
(*e*) An ecosystem is modeled to show that the concept of *system resilience*, a measure of the system's ability to absorb perturbations and recover, is a useful parameter for system design. A further inquiry is directed at the role of compressing large-scale simulation studies into a scale appropriate for policy analysis. An example of a forest management system is given.
(*g*) Policy analysis by compression appears a feasible procedure when certain structural characteristics of the problem specification are met. It is shown that the amount and frequency of insecticide spraying for forest/pest management can significantly be reduced if spray is initiated at *low* levels of larval density.

045-10113-800-33

STANDARDS, OPTIMALITY AND RESILIENCE IN WATER-RESOURCE MANAGEMENT

(*b*) OWRT, Department of the Interior.
(*d*) Theoretical, applied.
(*e*) A systematic effort to study the role of complexity, redundancy and robustness of mathematical models used in the design and operation of "optimal" or "near-optimal" water-resource systems. A case study from the Connecticut River Basin will be taken.
(*g*) Preliminary results suggest that many mathematical models for water-resource system design are too detailed and too complex for the data bases and policy options typically available.

045-10114-860-30

TO ENHANCE ONGOING STUDIES OF MONITORING WATER QUALITY AND DETECTING TRENDS THROUGH ANALYSIS OF ECOSYSTEM RESILIENCE

(*b*) U.S. Geological Survey.
(*d*) Theoretical, applied.
(*e*) An inquiry into the role of mathematical models for designing data network systems and water-resource schemes for water-quality management, with particular reference to rebound and recovery of large-scale environmental programs.
(*g*) None available at this time.

UNIVERSITY OF HAWAII, J. K. K. Look Laboratory of Oceanographic Engineering, Department of Ocean Engineering, 811 Olomehani Street, Honolulu, Hawaii 96813. John Thomas O'Brien, Director of the Laboratory. (Direct report requests to: The Director)

046-08121-420-60

MEASUREMENT OF OCEAN WAVE-INDUCED WATER PARTICLE KINEMATICS

(*b*) National Sea Grant Program, NOAA.
(*c*) R. A. Grace.
(*d*) Experimental project in the ocean to examine the accuracy of the predictions of the linear and stream function theories related to peak wave-induced water particle velocities and accelerations near the sea bed.
(*e*) Kinematics measured by a ducted impeller meter 1.5 feet above the bottom in 37 feet of water. Wave conditions obtained from a spiral-wound, resistance gage.

(*f*) Completed.
(*g*) Linear and stream function theories both accurate for velocities but considerably in error for accelerations.
(*h*) **Near-Bottom Water Motion Under Ocean Waves,** R. A. Grace, *Proc. 15th Intl. Conf. on Coastal Engrg.*, Honolulu, Hawaii, July 1976.

046-09277-420-44

PIPELINE SURVIVAL UNDER OCEAN WAVE ATTACK

(*b*) National Sea Grant Program, NOAA.
(*c*) R. A. Grace.
(*d*) Experimental study in the ocean to obtain wave force coefficients for a submarine pipe parallel to the wave fronts.
(*e*) Test pipe made of steel, 16 inches in diameter and 17.5 feet long. Length of instrumented section–39.5 inches. Pipe mounted on base set on bottom in 37 feet of water. Kinematics measured with a ducted current meter and wave conditions with a resistance wire gage.
(*f*) Data taking completed; final report in preparation.
(*g*) Maximum force coefficients in horizontal and vertical directions independent of Reynolds number, pipe clearance, and roughness, but correlated with modified Keulegan-Carpenter period parameter.
(*h*) **Wave Force Coefficients from Pipeline Research in the Ocean,** R. A. Grace, S. A. Nicinski, *Proc. 8th Ann. Offshore Tech. Conf.* **3,** Houston, Tex., May 1976, pp. 681-694.

046-09278-520-00

DYNAMIC RESPONSES OF MOORED SHIPS DUE TO WAVE ACTION

(*c*) L. H. Seidl and T. T. Lee.
(*d*) Experimental in the laboratory and numerical type studies as applied research and for use in Master's level papers (not thesis).
(*e*) Predict the dynamic responses of tankers moored at sea berth subjected to wave excitations from various headings. Regular and group waves were generated in a seakeeping and wave basin (42 ft wide, 64 ft long, and 4 ft high) for both deep water and shallow water conditions so as to excite spread-moored ship model at 1:100 scale of a 39,200-ton tanker and another at 1:100 scale of a 313,000-ton tanker. Ship model motions in six degrees of freedom were measured and compared with those predicted numerical for the prototypes.
(*f*) Completed.
(*g*) Agreement between numerical predictions and experimental measurements is considered good although there is some scattering of data points perhaps due to model scale, and nonlinear effects. The numerical technique is appliable to ships moored in regular waves and group waves. It predicts the slow-drift oscillations which must be taken into consideration in the design of sea berths. The test results for both water depth to draft ratio of 1.20 and 1.56 are presented in unit amplitude responses of ship motions (sway, surge, heave, pitch, roll, yaw, and slow drift oscillations) as a function of wave period. The effect of the bottom on the virtual mass and moment inertia is evident for the small water depth to draft ratio of 1.20. A Master of Science level research paper was completed covering laboratory study of a 1:100 scale model fo a 260,000-ton supertanker in a six point symmetric moor and subjected to head-on and beam-on regular and group waves for water depth to ship draft ratio of 1.2 and 1.5. Displacements in the six modes of motion were measured and steady state drift mooring forces were calculated from the measured displacements. From the data, a reflection coefficient, R, indicating the relative drift force was determined and presented in graph form as a function of incident wave period. It is found that the drift force is amplified in the vicinity of the natural period of heave, pitch and roll. Tank effects such as especially undesirable reflections from tank boundaries must be reduced to a minimum for similar tests.
(*h*) **SEABERTH–A Program for Calculation of Motions and Mooring Forces,** L. Sugin, L. H. Seidl. Reprints of *Ocean Engrg. II Conf.*, Univ. of Delaware, Newark, Del., June 9-12, 1975.
Physical and Mathematical Modeling on Dynamic Responses of Supertankers Moored at Seaberth Subjected to Wave Action, T. T. Lee, Volume 1 (text, appendices A, B, C; 127 pp.) and Volume 2 (Appendix D; 299 pp.); unpublished manuscripts.
Drift Forces on Moored Vessels of Minimum Draft Clearance, A. J. James, *Master of Science Paper*, Dept. of Ocean Engrg., Univ. of Hawaii, May 4, 1976; 54 pages.

046-09279-520-88

DYNAMIC RESPONSES OF SEA BERTH-MOORED TANKERS DUE TO WAVE ACTION

(*b*) Osaka City University, Osaka, Japan, and University of Hawaii.
(*c*) T. T. Lee.
(*d*) Experimental and applied research, and numerical techniques.
(*e*) Provide a method to predict dynamic response of supertankers moored at a sea-berth excited by water waves and related mooring forces and impact forces induced to berthing structures. The study involves an experimental study of a 200,000 DWT supertanker at 1:40 model scale measuring impact forces, mooring forces and ship motions as excited by beam-on waves.
(*f*) Completed.
(*g*) Investigations covered experimental studies of 1:40 scale model of 313,000-ton tanker at University of Hawaii (refer to 046-09278-520-00). Impact forces, mooring forces, and ship motions were measured at Osaka while only ship motions were measured at Hawaii. These experimental results were used to validate the mathematical model developed by L. H. Seidl at University of Hawaii. It was found that the numerical model is valid and the values are approximately 15 percent higher than the results from the physical models. Other major contributions include: effects of elastic characteristics of dolphin-fender systems on hydrodynamics; effects of elastic characteristics and initial tensions of mooring lines on impact forces, mooring forces, ship motions, and effects of wave characteristics on these forces and motions. The unit amplitude response operators obtained by either experiments or theory can be used to predict impact forces, mooring forces and slow-drift ship oscillation for engineering purposes. The information for the regular waves can be used to predict the responses for irregular waves at least for the frequency domain solutions. Time domain predictions will be applicable when coupling of motions is not significant. Experimental and numerical results agree reasonably well. Some of the discrepancies are due perhaps to: (a) the uncertainty of values for hydrodynamic mass and damping for use in the mathematical model; (b) the necessity of knowing whether or not the tanker is "breast-on" or "breast-off" the sea berth; thus the *effective* spring constant of dolphin-fender-mooring system should be used in calculations; (c) consideration of a change in free oscillation when certain mooring lines are broken; and, (d) scale effects of the type expected in the model studies.
(*h*) **Impact Forces, Mooring Forces and Motions of Supertankers at Offshore Terminal Subjected to Wave Actions,** S. Nagai, K. Oda, T. T. Lee, *Proc. XXIVth Intl. Navigation Congress*, Leningrad, Sept. 6-14, 1977.
Studies on Dynamic Responses of Supertankers Moored at Seaberth Subjected to Wave Action, T. T. Lee, *Ph.D. Dissertation*, Osaka City Univ., Japan, June 1976, 114 pages.
Scale Effects on Physical/Mathematical Modeling, T. T. Lee, *Proc. Symp. Modeling Techniques for Waterways, Harbors, and Coastal Engrg.*, San Francisco, Calif., Sept. 3-5, 1975, 20 pages.

046-09280-420-52

OPERATIONAL SEA STATE AND DESIGN WAVE CRITERIA FOR OCEAN THERMAL ENERGY CONVERSION PROJECTS

(*b*) Energy Research and Development Administration (ERDA).
(*c*) Prof. Charles L. Bretschneider.
(*d*) Office investigation, i.e., literature review and compilation: also numerical prediction.
(*e*) Identify and evaluate sources of information on wind, wave and current pertinent to the design and operation of an OTEC power plant off coast of USA including Hawaii but not Alaska and in a 40 degree wide belt centered on the Equator; predict these excitations for few particular locations.
(*g*) About one-hundred-sixty sources of information have been identified and published ranging from professional papers through periodicals, charts and atlases to books, especially "Ocean Wave Statistics," 1966 National Physical Lab in England and "Summary of Synoptic Meteorological Observations," 1973-75 of U.S. Naval Weather Service. There is much better information in areas offshore USA–excluding Hawaii–and the Arabian-MidIndian-Bengal-South China Sea area than in Equator-to-south-20 degree area where deficiencies are notable. More hindcasts are recommended for most areas especially those where hurricanes or typhoons are likely and where a dominant current exists. Examples have been published of application of state-of-the-art for predicting deep ocean currents and winds and the waves that they generate including extremes. Hindcasting for particular areas has begun including off Hawaii, Key West, New Orleans and Puerto Rico.
(*h*) **Operational Sea State and Design Wave Criteria for Ocean Thermal Energy Conversion Projects; Literature Available and Prediction Techniques for,** C. L. Bretschneider, Principal Investigator, and J. M. Cherry, T. K. Pyles, R. E. Rocheleau, B. B. Scott, E. E. Tayame, Graduate Students. *TR-39*, J. K. K. Look Lab., Univ. of Hawaii, Mar. 1977, 520 pages.
Operational Sea State and Design Wave Criteria: State of the Available Data for USA Coast and Equatorial Latitude, C. L. Bretschneider, *Proc. 4th Ocean Thermal Energy Conversion Conf.*, published by Energy Research and Development Administration, Washington, D.C., June 1977.

046-09282-340-54

OCEAN THERMAL ENERGY CONSERVATION TYPE POWER PLANT OFF ISLAND OF HAWAII

(*b*) National Science Foundation; Energy Research and Development Administration; and Department of Planning and Economic Development of State of Hawaii.
(*c*) Karl H. Bathen.
(*d*) Field investigation and numerical modeling; applied research; some of material to be used in Master's thesis.
(*e*) Define physical characteristics of the area in the Pacific Ocean offshore Keahole Point (N19-45 W156-04) on leeward side of the Island of Hawaii as potential site for an OTEC type power plant (likely floating) of 100 to 240 mega-watt capacity. Purpose of the study is to define the oceanographic conditions, and impact on the environment–physical, social and economic–of the OTEC Plant. It is concluded that the area is exceptionally seakindly with a large hot-cold water temperature differential relatively nearshore to a sympathetic population and hence a most promising one for OTEC Plant operation. The study off Keahole Point continues, e.g., thru 1978 it will include in situ observations at 2,000 ft depth of water temperature and salinity and current velocity for the Plant in general, and in particular tests off the Point of the bio-fouling of the heat-exchanger (under Prof. J. G. Fetkovich of Carnegie-Mellon U. and Prof. F. C. Munchmeyer of U. of Hawaii) and numerical prediction of sea and current state and criteria for operation and design of the Plant structure (under Prof. C. L. Bretschneider of U. of Hawaii).
(*h*) **Evaluation of Oceanographic Aspects and Environmental Impact of Nearshore Ocean Thermal Energy Conversion Plants on Sub-Tropical Hawaiian Waters,** published by Center for Engrg. Research; Univ. of Hawaii; K. H. Bathen, et al., NSF-RANN Grant AER-74-17421-A01, Apr. 1975, 130 pages.; K. H. Bathen; period June 75-Oct. 75. *Final Report to Dept. Planning and Economic Development*, State of Hawaii, Nov. 1975, 80 pages; K. H. Bathen, presented *Fall 1975 Mtg. Amer. Geophys. Union*, San Francisco, Nov. 1975, 16 pages.
Oceanographic and Socio-Economic Impact of a Nearshore Ocean Thermal Conversion Power Plant in Hawaii, K. H. Bathen, *LOOK LAB/HAWAII* 5, 2, pp. 15-32, July 1975.

046-10050-420-44

WAVE ATTENUATION AND WAVE-INDUCED SETUP OVER SHALLOW REEF

(*b*) National Oceanic and Atmospheric Administration; Office of Sea Grant Program; Office of Marine Affairs Coordinator, State of Hawaii.
(*c*) T. T. Lee and F. Gerritsen.
(*d*) Field investigation; experimental and theoretical studies laboratory; applied research and Master's thesis.
(*e*) Improve understanding of the characteristics of water waves from deep ocean which break on a reef and then travel shoreward to runup on and reflect from a beach. The plan during September 77-78 is to complete water level measurements at seven points on 1/4-mile long reef-to-beach course on south shore Oahu (N21-17 W157-52) and in laboratory in 180'×4' wide tank; analyze measurements and refine mathematical model and compare output with that obtained by others; develop formula for predicting pertinent behavior together with graphical solution and predict for specific locations in Hawaii; publish final report.
(*f*) Started September 1975; to be completed August 1978.
(*g*) The typically offshore waves incident on the reef are swell with narrow banded spectrum. These tend to arrive in groups ("sets" in surfer jargon) which then are modulated at a beat frequency. As they shoal on the reef, typically secondary waves are formed indicating a very nonlinear wave process. The waves which reform inside the reef after breaking have multiple crests. Power spectra and cumulative energy spectra have been obtained for each of the seven water level measuring stations on the reef-to-beach ocean course along with percent of total energy isolines vs frequency and distance offshore in graphical form for each day of measurements in the ocean. Wave attenuation primarily is at the expense of the energy at the primary frequency. Nonlinear transfer of energy is evident, both to high frequencies as exhibited by the secondary harmonic, and to low frequencies, as exhibited by the surf beat. Such transfer is extremely important in a description of the dynamics of the waves within the reef-to-beach system. This phenomenon also has been observed in laboratory experiments at 1:12 scale mainly to determine the response functions for the different ocean measuring stations. Laboratory measurements are being analyzed to determine wave energy dissipation due to breaking and bottom friction using both spectral and zero up-crossing procedures in which secondary wave effects are considered; friction coefficient and breaking factor using linear and/or solitary wave theories especially to determine energy losses and evaluate the scale effects in the laboratory experiment (physical model). The formation of solitons will be modeled numerically using a controlled iteration technique to solve the Korteweg and de Vries equation which is inherently divergent and results compared with measurements. $H_s = 3.57\,\sigma + 0.10$ is the best fit between the height of the significant wave and a standard deviation (σ). Other parameters being evaluated include: wave height and set-up distribution versus distance offshore; wave height and wave period relationship effect of local wind on energy spectra; energy losses due to friction and wave breaking; effect of scale on response functions obtained from field and laboratory measurements.

254-330 O - 78 - 4

(*h*) **Wave Transformation Across the Coral Reef,** E. B. Thornton, T. T. Lee, K. P. Black. Presented *Fall Ann. Mtg. Amer. Geophys. Union*, San Francisco, Calif., Dec. 6-10, 1976.
Preliminary Finding from Wave Attenuation and Wave Induced Setup Over Shallow Reef Project, T. T. Lee, K. P. Black, *Working Paper 77-1*, J. K. K. Look Lab., Apr. 4, 1977.
Spectral Analysis and Zero Up-Crossing Program–User's Guide, K. P. Black, *Working Paper 77-2*, J. K. K. Look Lab., Mar. 1977.
Characteristics of Waves Reformed Shoreward After Breaking on a Reef; Ocean, Laboratory, and Mathematical Study Of, T. T. Lee, F. Gerritsen, K. P. Black, *TR-40*, J. K. K. Look Lab. (in preparation).

046-10051-490-88

LABORATORY INVESTIGATION ON OCEAN THERMAL ENERGY CONVERSION (OTEC) SYSTEM

(*b*) Hawaii Natural Energy Institute.
(*c*) T. T. Lee.
(*d*) Experimental study in the laboratory and applied research.
(*e*) Assist in the design of an OTEC power plant located perhaps offshore Hawaii. It is planned to investigate the effect of the OTEC system on ambient ocean physical characteristics and also the effects of changes in ambient ocean stratification on OTEC plant efficiency by measurements in a very large and deep circular tank (40 ft high and 30 ft in diameter) at J. K. K. Look Laboratory of the flow-temperature field around the water intake-outlet subsystem. Measurements will be compared with predictions made using a numerical model being developed by Ph.D. candidate.
(*f*) Started September 1975 with August 1978 as estimated completion date.
(*g*) A working model was constructed which demonstrates the principle of operation of an OTEC power plant (it is not suitable for use in the measurement program). Laboratory simulation facilities are under construction. Data acquisition system is being designed.
(*h*) **Oceanographic Engineering Research on Ocean Thermal Energy Conversion for Hawaii,** T. T. Lee, K. H. Bathen. Proposal for Year 1977-78 to Univ. of Hawaii Sea Grant Program dated Feb. 1977.

046-10052-470-70

SITE SELECTION AND CONCEPTUAL PLANNING OF JETFOIL TERMINAL FOR HAWAII KAI, MAUNALUA BAY, OAHU

(*b*) Kentron Hawaii, Inc. of Honolulu, Hawaii.
(*c*) T. T. Lee.
(*d*) Engineering investigation in ocean and office and applied research.
(*e*) Determine technical feasibility and rank-of-merit of each of five possible sites; provide conceptual design for Terminal at the best site including bill of materials. The State of Hawaii is considering jetfoil-commuter service between Hawaii Kai and downtown Honolulu about 15 sea-miles west.
(*f*) Completed (June 23, 1975-August 3, 1975).
(*g*) The study covers factors such as winds, waves, currents, tsunamis, storm surge, tides, seiche, littoral drift, and ship motions; also, dredging requirements, geological climate, and ship maneuverability at the Terminal site. A computer program was developed to predict the motions of the jetfoil (Boeing 929) excited by waves of different heading and frequency for particular water depth to jetfoil draft ratios. Unit amplitude response operators in surge, heave, and pitch are presented and used to predict onset of motion sickness in humans as a parameter in the selection of the most appropriate berth orientation with minimum motion of the jetfoil at zero speed.
(*h*) **Site Selection and Conceptual Design for Hawaii Kai Jetfoil Terminal in Maunalua Bay, Oahu,** T. T. Lee, A. L. James, R. J. Merchant, *Tech. Rept.* **36,** J. K. K. Look Lab., Aug. 1975, 136 pages.

046-10053-470-60

SHIP-GENERATED WAVES IN NAVY MARINA AT PEARL HARBOR

(*b*) Harbors Division, Department of Transportation, State of Hawaii.
(*c*) T. T. Lee.
(*d*) Field investigation and office study and applied research.
(*e*) Determine effect on small boats as berthed in the Marina of waves generated by ferry boats passing nearby. The State of Hawaii is considering a ferry boat commuter service between downtown Honolulu and the Aloha Sport Stadium on shores of Pearl Harbor about 15 sea-miles west with harbor terminal near to the Marina.
(*f*) Completed in period January thru April 1976.
(*g*) Ship waves were generated by ferry boats of 180 ton displacement sailing into and out of the proposed landing terminal and comprehensive, correlated measurements of these waves (excitations) and motions (responses) of small craft in the Marina were made. The time-history of the ship-waves from area of generation to the berths of the Marina was recorded on aerial photographs from a helicopter overhead. Two ferry boats under light load and full load conditions and cruising at two different routes at a variety of speeds from 6 to 14 knots were used off the Marina. Based on the data analyzed, it is concluded that the effect on the Marina and its floating craft and piers of ferry operation to and from Aloha Stadium following the "Design Route" would not be significant at cruising speed of 6 knots or less and would be tolerable at up to 8 knots. Thus, the wave energy dissipator (breakwater) is considered unnecessary. The correlated measurements should be useful to marina designers generally.
(*h*) **Ship-Generated Waves in Navy Marina at Pearl Harbor,** T. T. Lee, *Tech. Rept. No. 38*, J. K. K. Look Lab., Apr. 1976, 50 pages.
Effect of Ship-Generated Wave on Marina Design, T. T. Lee, presented in Honolulu at the *Hawaii Reconvene Session (Oct. 23-25, 1977) of the Natl. Amer. Soc. Civil Engrs. Convention*, San Francisco, Calif., Oct. 17-21, 1977.

046-10054-420-00

WAVE-INDUCED INSTABILITY OF CONCRETE CUBES

(*c*) R. A. Grace.
(*d*) Experimental investigation in the ocean of the wave-induced kinematical conditions necessary to initiate motion of concrete cubes of various sizes (1 to 4 1/2 inches) and various specific gravities.
(*e*) Site in 37 feet of water. Blocks set on a concrete slab. Kinematics obtained by a ducted current meter. Observer diver used to signal movement of cubes.
(*f*) Completed.

046-10055-420-00

WAVE FORCES ON SUBMERGED SPHERES

(*c*) R. A. Grace.
(*d*) Experimental, field project on wave-induced forces on a sphere. Maximum-force, drag, and inertia coefficients are derived. Master's paper project.
(*e*) The sphere was 29 inches in diameter, attached to a 5-foot-long cantilever mounted vertically on a ballasted steel base. Strain gages on the cantilever permitted force-measuring. Water depth 37 feet.
(*f*) Completed.
(*g*) Excellent correlation of maximum-force coefficient with adapted Keulegan-Carpenter period parameter.
(*h*) **Inertia and Drag Coefficients for a Submerged Sphere,** G. Zee, *M.S. Plan "B" Paper*, Dept. of Ocean Engrg., Univ. of Hawaii, 60 pages, Dec. 1976.

046-10056-420-60

PRESSURE VARIATIONS UNDER WAVES

(*b*) State of Hawaii, Marine Affairs Coordinator's Office.
(*c*) R. A. Grace.

(*d*) Experimental, field and laboratory investigation of the success of the linear and second-order cnoidal wave theories in predicting surface wave heights from pressure head variations near the bottom.
(*e*) Field study in Hawaii in 37 feet of water. Laboratory study at Oregon State University with depths of 9.5 and 11.5 feet.
(*f*) Data collection completed; report in preparation.

UNIVERSITY OF HAWAII AT MANOA, College of Tropical Agriculture, Department of Agricultural Engineering, 3131 Maile Way, Honolulu, Hawaii 96822. Professor I-Pai Wu.

047-09025-840-00

DEVELOPMENT OF METHODS FOR OPTIMAL IRRIGATION DESIGN AND OPERATION

(*e*) Optimal design of conduit system with diverging branches, using dynamic program.
(*h*) **Design of Conduit System With Diverging Branches,** K-P. Yang, T. Liang, I-P. Wu, *J. Hydraul. Div. ASCE* **101**, HY1, *Proc. Paper 11080*, pp. 167-188, Jan. 1975.

047-09026-840-00

TRICKLE IRRIGATION TO IMPROVE CROP PRODUCTION AND WATER MANAGEMENT

(*e*) Hydraulic analysis of lateral lines, submain and main lines of a drip irrigation system.
(*h*) **Design of Drip Irrigation Line,** I-P. Wu, H. M. Gitlin, *HAES Tech. Bull. 96*, Univ. Hawaii, 29 pages, June 1974.
Drip Irrigation Design Based on Uniformity, I-P. Wu, H. M. Gitlin, *ASAE Trans.* **17**, 3, pp. 429-432, 1974.
Design Charts for Drip Irrigation Systems, I-P. Wu, H. M. Gitlin, *Proc. 2nd Intl. Drip Irrigation Congr.*, San Diego, Calif., pp. 305-310, July 1974.
Energy Gradient Line for Drip Irrigation Laterals, I-P. Wu, H. M. Gitlin, *J. Irrigation and Drainage Div., ASCE* **101**, IR4, pp. 323-326, Dec. 1975.
Design of Drip Irrigation Main Lines, I-P. Wu, *J. Irrigation and Drainage Div., ASCE* **101**, IR4, pp. 265-278, Dec. 1975.
Irrigation Efficiencies of Surface, Sprinkler and Drip Irrigation, I-P. Wu, H. M. Gitlin, *Proc. 2nd World Congress, Intl. Water Resources Assoc.* **1**, New Delhi, India, pp. 191-199, Dec. 1975.

UNIVERSITY OF HOUSTON, Cullen College of Engineering, Houston, Tex. 77004. Dr. Philip G. Hoffman, University President; Dr. Abraham E. Dukler, Dean of Engineering.

048-10195-630-70

INVESTIGATION OF HYDRAULIC PULSING IN A PITOT PUMP WITH CENTRIFUGAL SEPARATOR AND JET STIRRING VANE

(*b*) Kobe, Inc., California.
(*c*) Dr. Kurt M. Marshek, Department of Mechanical Engineering.
(*d*) Theoretical and experimental; applied research and design-development; Master's and Doctor's theses.
(*e*) The cause of exit flow hydraulic pulsing and its relation to the pump-filter geometry and flow variables will be determined. Mathematical methods of describing the flow of solid particles and the fluid itself are being studied so that the pump-filter design can be optimized with regard to flow, pressure, noise and strength.

048-10196-050-50

ACOUSTIC MEASUREMENTS IN NORMAL JET IMPINGEMENT

(*b*) Theoretical Acoustics Branch, NASA, Langley Research Center.
(*c*) Dr. Stanley J. Kleis, Department of Mechanical Engineering.
(*d*) Experimental, basic research.
(*e*) Far field acoustics measurements of the noise produced by subsonic jets impinging normally on a large flat surface were made for small nozzle to plate spacings. Both a uniform and fully developed pipe flow velocity exit condition were tested. The nozzle to plate spacing normalized by the jet exit diameter was varied from 0.75 to 7.0 for a Mach number of 0.28. The motivation for the study was to provide a data base for a relatively simple flow field for comparison with noise prediction techniques based on vorticity transport in the flow impingement region. The small dimensionless nozzle to plate spacings were chosen such that the potential core (for the uniform jet) extended into the impingement region on the surface.
(*g*) All results are for an exit Mach number of 0.28 and a nominal exit diameter of 2.2 cm. Measurement of overall sound power level indicates a large (12 db) increase above a free jet as the dimensionless nozzle to plate spacing is reduced to a value near unity for the uniform jet. A similar increase (9 db) occurs for the fully developed pipe flow condition. Although the overall sound power level exhibits a smooth variation with nozzle to plate spacing, the directivity patterns change very rapidly. The directivity patterns are quite distinct (6-7 db from maximum to minimum) and complex. They have been found to be radially independent. The radial independence indicates that the patterns are not caused by the cancellations and reinforcements of narrow band noise or pure tones.
(*h*) **Acoustics Measurements in Normal Jet Impingement,** *First Semi-Annual Rept.*, NASA Research Center, contact correspondent.

048-10197-020-20

EFFECT OF AXISYMMETRIC CONTRACTION SHAPE AND RATIO ON THE INCOMPRESSIBLE TURBULENT FLOW

(*b*) Office of Naval Research.
(*c*) A. K. M. Fazle Hussain, Professor of Mechanical Engineering.
(*d*) Experimental; basic research.
(*e*) The effects of the axisymmetric contraction shape and contraction ratio both with and without upstream grid on the incompressible free-stream turbulence havebeen determined experimentally. Primary motivation was nozzle design for jet study.
(*g*) Turbulence modification in the contraction is not affected by the contraction shape; the exit boundary layer mean and turbulence characteristics, however, as well as the departure from equipartition within the nozzle, depend on the contraction shape. The exit longitudinal turbulence intensity does not decrease for contraction ratios c greater than aobut 45 while the lateral turbulence intensity continues to decrease further. The data demonstrate the inadequacy of the linear (Batchelor-Proudman-Ribner-Tucker) theory in predicting the effect of a contraction on the turbulence structure.
(*h*) **Effects of the Axisymmetric Contraction Shape on Incompressible Turbulent Flow,** A. K. M. F. Hussain, V. Ramjee, *J. Fludis Engr.* **98**, pp. 58-69, 1976.
Influence of the Axisymmetric Contraction Ratio on Free-Stream Trubulence, V. Ramjee, A. K. M. F. Hussain, *J. Fluids Engr.* **98**, pp. 506-515, 1976.

048-10198-030-20

VORTEX SHEDDING FROM A CYLINDER IN THE PRESENCE OF FREE-STREAM PERTURBATIONS

(*b*) Office of Naval Research.
(*c*) A. K. M. Fazle Hussain, Professor of Mechanical Engineering.

(*d*) Experimental; basic research.
(*e*) The effects of free-stream turbulence and of sinusoidal free-stream pulsations of controlled frequencies and amplitudes on the periodic wake of a circular cylinder were studied by employing hot-wire and visualization techniques.
(*g*) The frequency-mean velocity (Berger's) relation is unaffected by the free-stream turbulence intensity. Sinusoidal pulsations up to 10 percent in amplitude of the free-stream velocity have no effect on the shedding frequency. At larger pulsations, shedding occurs at the pulsation frequency. Free-stream turbulence or pulsation cannot explain the "Tritton jump."
(*h*) **Vortex Shedding from a Circular Cylinder in the Presence of Free-Stream Disturbances,** A. K. M. F. Hussain, V. Ramjee, *Proc. 5th Canad. Congr. Appl. Mech.*, pp. 485-486, 1975.
Periodic Wake Behind a Circular Cylinder at Low Reynolds Number, A. K. M. F. Hussain, V. Ramjee, *Aero. Quart.* **27,** pp. 123-142, 1976.

048-10199-050-54

EFFECT OF THE INITIAL CONDITION ON THE TURBULENCE STRUCTURE IN A PLANE JET

(*b*) National Science Foundation.
(*c*) A. K. M. Fazle Hussain, Professor of Mechanical Engineering.
(*d*) Experimental; basic research; M.S. and Ph.D. theses.
(*e*) The effects of the characteristics of the initial (laminar and turbulent) boundary layers on the statistical measures of a plane free jet have been determined experimentally.
(*g*) The mean and turbulent velocities, virtual origins, jet width, mass flux, entrainment rate, etc., depend systematically on the initial condition. The momentum flux increases by up to 60 percent of the exit momentum flux, depending on the initial condition. This increase is attributed to the negative mean static pressure and has been confirmed by pressure measurements.
(*h*) **Effects of the Initial Condition on the Development of a Plane Turbulent Jet,** A. R. Clark, A. K. M. F. Hussain, *Proc. Soc. Engr. Sc.* **12.** pp. 1149-1158, 1975.
Upstream Influence on the Near Field of a Plane Turbulent Jet, A. K. M. F. Hussain, A. R. Clark, submitted for publication.

048-10200-050-54

VORTICITY WAVE IN A PLANE TURBULENT JET

(*b*) National Science Foudnation.
(*c*) A. K. M. Fazle Hussain, Professor of Mechanical Engineering.
(*d*) Experimental; basic research; Ph.D. thesis.
(*e*) The characteristics of the vorticity waves in the near field of a plane turbulent jet under controlled excitation have been investigated in the Reynolds number range 8,000-32,000 and the Strouhal number range 0.15-0.60.
(*g*) The wave fundamental amplitude attains its maximum value at the Strouhal number 0.18, at 4 slit-widths downstream from the exit. The wave amplitude and phase data in the near field free shear layer agree with the spatial stability theory of Michalke. The phase velocity data show that in the lower Strouhal number range the plane jet is nearly a nondispersive waveguide.
(*h*) **Organized Motions in a Plane Turbulent Jet Under Controlled Excitation,** A. K. M. F. Hussain, C. A. Thompson, *Proc. Soc. Engr. Sc.* **12,** pp. 341-352, 1975.

048-10201-050-54

ORGANIZED STRUCTURE IN A PLANE JET

(*b*) National Science Foundation.
(*c*) A. K. M. Fazle Hussain, Professor of Mechanical Engineering.
(*d*) Experimental; basic research; Ph.D. thesis.
(*e*) Wavenumber dependent phase velocities of large scales are being determined from double-Fourier transformation of measured space-time correlation in a plane jet.

048-10202-050-54

CONDITIONALLY SAMPLED MEASUREMENTS IN A PLANE TURBULENT JET

(*b*) National Science Foundation.
(*c*) A. K. M. Fazle Hussain, Professor of Mechanical Engineering.
(*d*) Experimental; basic research.
(*e*) The conditionally measured turbulence structure in a plane jet is being determined for different initial conditions.

048-10203-050-50

ACOUSTICS-TURBULENCE INTERACTION IN A CIRCULAR JET UNDER CONTROLLED EXCITATION

(*b*) NASA-Langley Research Center.
(*c*) A. K. M. Fazle Hussain, Professor of Mechanical Engineering.
(*d*) Experimental; basic research; Ph.D. thesis.
(*e*) The effects of sinusoidal excitations of controlled amplitudes and frequencies on the near field turbulence structures of circular jets have been investigated over a large range of unit Reynolds numbers, jet Reynolds numbers, Strouhal numbers, excitation amplitudes and initial conditions.
(*g*) Significant variations in the turbulence intensity, as well as integral measures, of the circular jet can be effected by small-amplitude excitations. Depending on excitation Strouhal numbers, the turbulence intensity in the jet can be increased or damped over the unpulsated jet.
(*h*) **Effect of Acoustic Excitation on the Turbulent Structure of a Circular Jet,** A. K. M. F. Hussain, K. B. M. Q. Zaman, *Proc. Interag. Symp. Univ. Res. Transp. Noise* **3,** pp. 314-326, 1975.

048-10204-050-20

VORTEX PAIRING IN A CIRCULAR JET UNDER CONTROLLED EXCITATION

(*b*) Office of Naval Research.
(*c*) A. K. M. Fazle Hussain, Professor of Mechanical Engineering.
(*d*) Experimental, basic research; Ph.D. thesis.
(*e*) The effects of controlled periodic excitation on the vortex pairing mechanism in a circular jet under controlled excitation are being carried out by both flow-visualization and hot-wire techniques.
(*g*) Vortex pairing in circular jets occurs in two modes, "the shear layer mode" and "the jet mode." Most intense organized activity in a circular jet is associated with the pairing process.
(*h*) **Vortex Pairing and Organized Structures in Axisymmetric Jets under Controlled Excitation,** K. B. M. Q. Zaman, A. K. M. F. Hussain, *Turb. Shear Flow*, Penn State U., pp. 11.23-31, 1977.

048-10205-000-54

EFFECT OF THE INITIAL CONDITION ON THE STRUCTURE OF THE FREE SHEAR LAYER

(*b*) National Science Foundation.
(*c*) A. K. M. Fazle Hussain, Professor of Mechanical Engineering.
(*d*) Experimental, basic research; Ph.D. thesis.
(*e*) The effects of initial momentum thickness Reynolds number and fluctual level on the evolution of an axisymmetric free shear layer have been investigated for initially laminar and turbulent boundary layers.
(*g*) Most discrepancies in published data on the free mixing layer can be explained as consequences of systematic variations of the initial condition.
(*h*) **Effects of the Initial Condition on the Axisymmetric Free Shear Layer,** A. K. M. F. Hussain, M. F. Zedan, submitted.

048-10206-160-20

THE FREE SHEAR LAYER TONE PHENOMENON

(*b*) Office of Naval Research and National Science Foundation.
(*c*) A. K. M. Fazle Hussain, Professor of Mechanical Engineering.
(*d*) The free shear layer tone mechanism induced by a hot-wire probe and a plane wedge has been studied for incompressible plane and axisymmetric free shear layers.
(*f*) The free shear layer tone mechanism is quite different from the widely investigated slit-jet edgetone. Detailed integral measures of the shear layer under edgetone, and the shear tone eigenvalues and eigenfunctions have been measured and found to be in reasonable agreement with spatial stability theory.
(*h*) **The Free Shear Layer Tone Phenomenon and Probe Interference,** A. K. M. F. Hussain, K. B. M. Q. Zaman, submitted.

048-10207-050-50

NOISE RADIATED FROM A JET UNDER CONTROLLED PERTURBATION

(*b*) NASA-Langley Research Center.
(*c*) A. K. M. Fazle Hussain and S. J. Kleis, Department of Mechanical Engineering.
(*d*) Experimental; applied research; M.S. thesis.
(*e*) The effect of controlled pulsation of the far-field noise of a high-speed subsonic jet is being studied.

048-10208-210-54

INSTABILITY OF TIME-DEPENDENT FLOWS IN STRAIGHT AND CURVED TUBES

(*b*) National Science Foundation.
(*c*) A. K. M. Fazle Hussain, Professor of Mechanical Engineering.
(*d*) Experimental; basic research; post-doctoral.
(*e*) The instability characteristics of periodically pulsed flows in straight and curved tubes are being studied experimentally.

048-10209-420-54

NONLINEAR GRAVITY WAVE INTERACTION

(*b*) National Science Foundation.
(*c*) Asst. Prof. James D. A. van Hoften, Department of Civil Engineering.
(*d*) The project is an experimental basic research study, which will produce one Masters thesis and one Doctoral dissertation.
(*e*) Three phases of water wave interaction will be studied in a laboratory wave tank. The existence of a two-component wave will be investigated as its nonlinear effects increase to the point of micro breaking. Additionally the initiation of turbulence by wave action will be examined by a wave following hot-film anemometer.

048-10210-130-52

MODELING FLOW REGIMES IN TWO PHASE GAS LIQUID FLOW

(*b*) U.S. Energy Research and Development Administration.
(*c*) A. E. Dukler, Professor, Chemical Engineering Department.
(*d*) Experimental, theoretical, basic research.
(*e*) Criteria for transition between the various flow regimes observed in two phase flow are developed based on the forces causing each of these transitions to take place. Studies are under way for vertical upward and horizontal study flow as well as during flow transients.
(*g*) Models have been evolved based on the physical mechanisms which are operative. The results have been generalized to cover the effects of pipe size, flow rates and fluid properties for the two situations of horizontal and vertical upflow.
(*h*) **A Model for Predicting Flow Regime Transitions for Horizontal and Near Horizontal Tubes,** Y. Taitel, A. E. Dukler, *AIChE J.* **22,** 47 (1976).
Flow Regime Transitions for Vertical Upward Gas-Liquid Flow: An Approach Through Physical Modeling, Y. Taitel, A. E. Dukler, *U.S. Nuclear Regulatory Comm. Rept., NUREG-0162*, 48 pages (1977).

048-10211-130-55

FLOW REVERSAL IN TWO PHASE, GAS LIQUID VERTICAL FILM FLOW

(*b*) U.S. Nuclear Regulatory Commission.
(*c*) A. E. Dukler, Professor, Chemical Engineering Department.
(*d*) Experimental, theoretical, basic research.
(*e*) A study of the role of the interfacial wave structure in the process of flow reversal or flooding for liquid films falling down the inside wall of a vertical tube.
(*g*) Interfacial shear created by countercurrent gas flow modifies the interfacial structure and flow reversal takes place without closure of the tube.
(*h*) **Statistical Characteristics of Thin Wavy Films: II. Studies of the Substrate and Its Wave Structure,** K. J. Chu, A. E. Dukler, *AIChE J.* **20,** pp. 695-706 (1974).
Statistical Characteristics of Thin Wavy Films: III. Structure of the Large Waves and Their Resistance to Gas Flow, K. J. Chu, A. E. Dukler, *AIChE J.* **21,** pp. 583-594 (1975).

048-10212-130-88

MECHANICS, HEAT AND MASS TRANSFER IN GAS-LIQUID SLUG FLOW

(*b*) American Institute of Chemical Engineering Design Institute for Multiphase Processing.
(*c*) A. E. Dukler, Professor, Chemical Engineering Department.
(*d*) Experiment, theoretical, applied research.
(*e*) Over a wide range of flow rate space, gas and liquid flowing simultaneously in horizontal tubes naturally distribute so that large slugs of liquid move rapidly down the pipe followed by a stratified liquid film superposed by a gas phase. Both the local flow rate and transport vary with time. The objective of the project is to model the unsteady flow (slug length, velocity, frequency, film height profile and velocity, gas velocity) and extend this work to heat and mass transfer.
(*g*) Two models have been developed from which the hydrodynamic characteristics of the slug flow can be predicted including the essential spacial features and frequency. This has been verified with experiment. A mathematical model has been developed to describe the unsteady state heat transfer process and validated experimentally.
(*h*) **A Model for Gas-Liquid Slug Flow in Horizontal and Near Horizontal Tubes,** M. G. Hubbard, A. E. Dukler, *Ind. Eng. Chem. Fund.* **14,** 337 (1975).
Heat Transfer During Gas-Liquid Slug Flow in Horizontal Tubes, T. Niu, A. E. Dukler, in press for *Proc. of OECD/NEA Specialists Mtg. on Transient Two Phase Flow*, Plenum Press (1977).
A Model for Slug Frequency During Gas-Liquid Slug Flow in Horizontal and Near Horizontal Pipes, Y. Taitel, A. E. Dukler, in press for *Int. J. Multiphase Flows*, (1977).

048-10213-130-54

DEPOSITION OF DROPLETS INTO MOVING LIQUID FILMS

(*b*) National Science Foundation; U.S. Nuclear Regulatory Commission.
(*c*) A. E. Dukler, Professor, Chemical Engineering Department.
(*d*) Experimental, theoretical, basic research.
(*e*) A gas phase moving over a liquid film generates droplets which are dispersed in the gas phase. The process of turbulent diffusion results in some of these drops being redeposited on the film. The objective of this research is

to discern the deposition mechanism for these large (1000$^+$ micron) drops in the presence of a wavy liquid film.

(*g*) A stochastic model for deposition of small drops (< 100 μ) has been developed. A measurement technique is now operative which uses a two color, two dimensional laser velocimeter which permits direct measurement of droplet velocities.

(*h*) **Deposition of Liquid on Solid Dispersions from Turbulent Gas Streams,** P. Hutchenson, G. Hewett, A. E. Dukler, *Chem. Eng. Sci.* **26,** 419 (1971).
Lagrangian Simulation of Dispersion in Turbulent Shear Flow Using a Hybrid Computer, N. Lee, A. E. Dukler, *AIChE J.* **22,** 449 (1976).

048-10214-130-52

TWO PHASE FLOW IN GEOTHERMAL WELLS

(*b*) U.S. Energy Research and Development Administration.
(*c*) A. E. Dukler, Professor, Chemical Engineering Department.
(*d*) Experimental, applied research.
(*e*) The factor controlling the rate of production of a geothermal well is the pressure gradient due to hydrostatic pressure. In this work the objective is to model the void fraction distribution for each flow pattern and to test these models experimentally.
(*g*) Physical modeling completed. Test loop completed. Development of cross-sectional average void fraction instrument in progress.

048-10215-120-00

WASHING INCOMPRESSIBLE FILTER CAKES WITH NON-NEWTONIAN LIQUIDS

(*b*) R. W. Flumerfelt and F. M. Tiller, Professors of Chemical Engineering.
(*d*) Theoretical and applied.
(*e*) Displacement washing of liquids in incrompressible beds is being investigated. Two extremes of behavior are considered. A non-Newtonian liquid is displaced by a Newtonian liquid and vice versa. Calculations have been made for both constant pressure and constant rate operation. Power low fluids form the basis for displacement calculations. Non-Newtonian fluids displace Newtonian fluids with a flat velocity profile resulting in efficient plug-life washing. Conversely, Newtonian fluids produce a thin needle-like penetration along the axis of flow when they displace high viscosity Newtonian liquids resulting in poor washing.

048-10216-120-00

DISPLACEMENT OF NEWTONIAN FLUIDS BETWEEN PARALLEL PLATES AND IN CIRCULAR TUBES

(*c*) R. W. Flumerfelt, Professor of Chemical Engineering.
(*d*) Studies have been made of the displacement of one power-law fluid by another in both parallel plate and circular tube configuration. Methods were developed for prediction of pressure flow rate-time relationships. The effects of wide variation in viscosity ratios and power-law exponents were investigated. The work was done as a part of a large program aimed at determining displacement characteristics in complex porous media.
(*e*) Completed.

048-10217-290-54

GROWTH OF CHAIN-LIKE PARTICLE DEPOSITS DURING AEROSOL FILTRATION IN FIBROUS MEDIA

(*b*) National Science Foundation.
(*c*) A. C. Payatakes, Assoc. Professor of Chemical Engineering.
(*d*) Experimental and theoretical, basic research, M.S. and Ph.D. theses.
(*e*) In the initial stages of deposition of aerosols on fibers, particles form chain-like dendrites rather than uniform random deposits. Mathematical models have been developed to describe the deposition. Experimental verification of the models is in progress.

048-10218-290-54

SEPARATION OF MINERAL RESIDUE AND UNCONVERTED CARBON FROM LIQUIFIED COAL

(*b*) National Science Foundation.
(*c*) F. M. Tiller, Professor of Chemical Engineering.
(*d*) Theoretical and applied; experimental; M.S. and Ph.D. theses.
(*e*) Study is aimed at uncovering relationships involving flow through compressible filter cakes encountered in coal liquification, and developing basic information for a new approach to continuous, thin-cake, high-pressure, staged filtration.
(*h*) **Delayed Cake Filtration,** F. M. Tiller, K. S. Cheng, *Filtration and Separation* **14,** pp. 13-18 (1977).
Characteristics of Continuous Staged, Delayed Cake Filter, F. M. Tiller, *Ibid,* in press (1977).
High-Pressure, Thin-Cake, Staged Filtration, A. Bagdasarian, F. M. Tiller, J. Donovan, *Ibid,* in press (1977).

048-10219-870-00

RECOVERY OF VALUABLE MATERIALS OCCURRING IN DILUTE FORM

(*c*) F. M. Tiller, Professor of Chemical Engineering.
(*d*) Experimental and applied.
(*e*) Recovery of valuable materials such as titanium dioxide which are discarded in wastewater is being investigated. A deep granular bed is used to remove the particulates. Concentration of the dilute slurry is accomplished by minimizing the quantity of back wash. Estimates indicate the possibility of multiplying the initial concentration by a factor of 50 or more. Thus, 100 rpm could be changed into 5000 rpm which is then in the range of normal filtration.

048-10220-070-54

CREEPING NEWTONIAN FLOW IN PERIODICALLY CONSTRICTED UNIT CELLS

(*b*) National Science Foundation.
(*c*) A periodically constricted cell model was developed to represent realistically flow through porous media. The unit cells have random dimensions and orientation which can be determined by capillary suction measurements. A collocation solution of creeping Newtonian flow was used to produce velocity and pressure profiles. Analytical expressions were obtained for local variable and then were integrated to give pressure drop. Predictions were found to be in agreement with experimental data.
(*h*) **A New Model for Granular Porous Media, Part I,** A. C. Payatakes, C. Tien, R. M. Turian, *AIChE J.* **19,** 58 (1973); Part II, *Ibid* **19,** 67 (1973).
Application of Porous Media Models to the Study of Deep-Bed Filtration, A. C. Payatakes, R. Rajagopalan, C. Tien, *Can. J. Chem. Eng.* **52,** 722 (1974).

HOWARD UNIVERSITY, Department of Civil Engineering, Washington, D.C. 20059. Dr. I. W. Jones, Chairman of Civil Engineering; Dr. C. L. Yen, In Charge of Hydraulics Laboratory.

049-10067-810-05

RECESSION FLOW THROUGH POROUS MEDIUM WITH IMPERVIOUS STRATUM

(*b*) USDA-ARS Hydrograph Laboratory.
(*c*) Professor C. L. Yen.
(*d*) Experimental, analytical, basic research for Master's thesis.
(*e*) Investigate the effects of physical factors, such as slope, length and thickness of porous media, resting on an impervious stratum, on the recession flow and its recession coefficient.
(*f*) Completed.

049-10068-810-05

MACROPORE EFFECTS ON INFILTRATION

(*b*) USDA-ARS Hydrograph Laboratory.
(*c*) Professor C. L. Yen.
(*d*) Analytical basic research for Master's thesis.
(*e*) To simulate by digital computer the advancement of soil moisture front under various macropore conditions and to determine the rate of water infiltrating into the soil from these simulations.
(*f*) Completed.

049-10069-310-54

FLOOD ROUTING IN FLOODPLAIN CHANNELS–FIELD TESTING

(*b*) U.S. National Science Foundation (in cooperation with National Science Council of the Rep. of China).
(*c*) Professor C. L. Yen.
(*d*) See WRRC **11**, 2.0132.

049-10070-830-36

EFFICIENCY OF OFF-STREAM DETENTION-RETENTION MEASURES FOR SEDIMENT CONTROL

(*b*) U.S. Environmental Protection Agency.
(*c*) Professor C. L. Yen.
(*d*) See WRRC **11**, 2.0363.

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HYDROCOMP, 1502 Page Mill Road, Palo Alto, Calif. 94304.

051-0379W-830-00

BASIN MODELING OF SOIL LOSS AND SEDIMENT TRANSPORT

(*e*) For summary, see Water Resources Research Catalog **11**, 2.0355.

051-0380W-870-00

REFINEMENT AND VERIFICATION OF THE PESTICIDE TRANSPORT AND RUNOFF MODEL WITH DEVELOPMENT OF SUB-MODELS FOR TRANSPORT OF PLANT NUTRIENTS

(*e*) For summary, see Water Resources Research Catalog **11**, 5.0250.

051-0381W-800-00

PLANNING AND MODELING FOR URBAN WATER RESOURCES MANAGEMENT

(*e*) For summary, see Water Resources Research Catalog **11**, 7.0003.

051-09912-810-36

COMPREHENSIVE PACKAGE FOR SIMULATION OF WATERSHED HYDROLOGY AND WATER QUALITY–HSP FORTRAN

(*b*) Environmental Research Laboratory, Environmental Protection Agency, Athens, Ga. 30601.
(*c*) Robert C. Johanson, Project Manager.
(*d*) Develop a comprehensive package for simulating water quality and quantity processes involved in the land, channel, and lake phases of the hydrologic cycle. Software package in FORTRAN incorporating all functions of Hydrocomp mathematical models: Hydrocomp Simulation Programming (HSP), Agricultural Runoff Management (ARM), and Nonpoint Source Pollutant Loading (NPS) in a structured framework.

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UNIVERSITY OF IDAHO, College of Engineering, Moscow, Idaho 83843. Robert R. Furgason, Dean.

052-09848-880-33

INTERACTING EFFECTS OF MINIMUM FLOW AND FLUCTUATING SHORELINES ON BENTHIC STREAM INSECTS

(*b*) Office of Water Resources Research, Department of Interior.
(*c*) E. Woody Trihey, Assistant Director, Idaho Water Resources Research Institute.
(*d*) Field investigation operation.
(*e*) Insect communities from both deep and shallow water areas will be investigated for the purpose of providing community analysis of the middle and lower mainstem of the Clearwater River. Numbers, composition and biomass will be determined and comparatively treated. Results will be analyzed in a manner that will attempt to generate a model that will depict quantitative, qualitative, and resilience characteristics of the insect community. Existing cross section and streamflow data will be used to develop site specific area-discharge relationships and verify a version of the HEC-2 model for the Clearwater.
(*g*) Data are available on insect populations.

052-09849-830-33

NATURAL SEDIMENTATION RATES FROM FORESTED WATERSHEDS

(*b*) Office of Water Resources Research, Department of Interior.
(*c*) J. G. King, Instructor, College of Forestry.
(*d*) Field investigation; applied, M.S. thesis.
(*e*) Proper management of Idaho's land and water resources requires the ability to predict the effects of land management practices on the quality of streamflow. This project is the first phase of a multiphase project. Phase I will be to determine the natural sedimentation rates from twelve forested watersheds in the Horse Creek drainage of central Idaho.
(*g*) Some data are available.

052-09850-840-82

APPLICATION OF AGRICULTURAL CHEMICALS THROUGH IRRIGATION SYSTEMS

(*b*) Idaho Potato Commission, Diamond Shamrock Chemical Company, Idaho Agricultural Experiment Station.
(*c*) Galen McMaser, Professor, Agricultural Engineering.
(*d*) Field investigation; development, M.S. thesis.
(*e*) A study of mixing, dilution and uniformity of application of agricultural chemicals injected into irrigation systems. A comparison with other methods of application will be made.
(*g*) This process compares very well with ground-rig application and gives less problems with toxicity on potato plants.

052-09851-220-61

EFFECTS OF SEDIMENT TRANSPORTATION ON THE DISTRIBUTION AND COLONIZATION OF STREAM INSECTS

(*b*) Idaho Water Resources Research Institute.
(*c*) Myron Molnau, Professor, Agricultural Engineering.
(*d*) Field investigation; applied research, M.S. thesis.
(*e*) Determine the capability of high mountain streams of the Idaho Betholith to transport sediment and to determine the ability of these streams to maintain suitable environment for the aquatic habitat of the streams.
(*f*) Completed.
(*g*) Bedload measurements on Knapp Creek indicate that the Meyer-Peter, Muller equation works satisfactorily for predicting bed load in this stream.

052-09852-830-61

EROSION RESEARCH FOR NORTHERN IDAHO-MODELING OF RUNOFF FOR EROSION STUDIES

(*b*) Idaho Water Resources Research Institute, Agricultural Research Service and Idaho Agricultural Experiment Station.
(*c*) Myron Molnau, Professor, Agricultural Engineering.
(*d*) Field investigation; applied research, M.S. thesis.
(*e*) Develop and test a computer simulation model for snowmelt and erosion that is applicable to the Palouse region.
(*g*) A computer model is operational and is being improved.

052-09853-840-36

EVALUATION OF PRACTICES AND SYSTEMS FOR IMPROVING THE QUALITY OF IRRIGATION RETURN FLOWS

(*b*) Environmental Protection Agency, Idaho Agricultural Experiment Station.
(*c*) D. W. Fitzsimmons, Professor and Head, Agricultural Engineering.
(*d*) Field investigation; operation, M.S. thesis.
(*e*) Purpose is to determine effectiveness of settling ponds, other tail water control systems and alternative water management practices in reducing nutrient losses and pollution from irrigated fields.
(*g*) Settling ponds remove more than 80 percent of the sediment from irrigation runoff.

052-09854-840-31

OPTIMIZING IRRIGATION SYSTEM DESIGN

(*b*) Bureau of Reclamation, Idaho Department of Water Resources.
(*c*) J. R. Busch, Associate Professor, Agricultural Engineering.
(*d*) Theoretical, applied research.
(*e*) Develop a methodology and computer model for optimum design or rehabilitation of irrigation systems.
(*g*) Computer model is presently being developed.

052-09855-070-34

SEEPAGE THROUGH PARTIALLY SATURATED SHALE WASTES

(*b*) Bureau of Mines, U.S. Department of Interior.
(*c*) G. L. Bloomsburg, Professor, Agricultural Engineering.
(*d*) Experimental; applied research, M.S. thesis.
(*e*) A computer simulation model for unsaturated flow is used to predict flow through waste shale piles.
(*g*) Field data have been used to verify the simulation. Laboratory data on hydraulic properties of retorted shale have been obtained.

052-09856-810-61

EFFECTS OF ANTECEDENT CONDITIONS OF FROZEN GROUND FLOORS

(*b*) Idaho Water Resources Research Institute.
(*c*) Myron Molnau, Professor, Agricultural Engineering.
(*d*) Field investigation; applied research, M.S. thesis.
(*e*) Identify hydrologic parameters that are important in distinguishing between frozen and unfrozen ground floods and use this in determining a procedure for predicting frozen ground floods.
(*f*) Completed.
(*g*) Discriminant analysis showed that the significant parameters are, number of days below 32 °F, freeze index, precipitation two days before freeze period, precipitation during freeze period, precipitation four days after thawing starts, and depth of snow on the ground before freezing starts.

052-09857-840-33

IRRIGATION WATER USE EFFICIENCY AND COST OF WATER AS FACTORS IN WATER MANAGEMENT OF IRRIGATION SYSTEMS IN IDAHO

(*b*) OWRT.
(*c*) C. C. Warnick, Professor, Civil Engineering.
(*d*) Field investigation; operation; M.S. thesis.
(*e*) This study is concerned with relations between cost of water and irrigation water efficiency in an extensive irrigated area serviced by the Snake River in Idaho. The investigation will cover some 20 irrigation companies or districts along the Snake River and will require some measurement of water to obtain necessary data.
(*g*) None at the present time.

052-09858-310-00

COMBINATION OF SHORT-TIME DETENTION STORAGE AND CHANNEL RENOVATION FOR COMMUNITY FLOOD CONTROL

(*c*) C. C. Warnick, Professor, Civil Engineering.
(*d*) For M.S. thesis.
(*e*) A study of planning and analytical methods to determine the best combination of detention reservoirs and degrees of channel improvement as flood control measures. The study is concentrating on Paradise Creek as it flows through Moscow, Idaho. The concept avoids the problem of large storage reservoirs and major channel modifications.
(*g*) A thesis will be finished in 1977.

052-09859-870-82

LARGE, DEEP-TANK TESTS OF FULL-SIZE AERATORS

(*b*) Northwest Pulp and Paper Association.
(*c*) M. L. Jackson, Professor, Chemical Engineering.
(*d*) Experimental; applied research, M.S. thesis.
(*e*) A 75 ft column has been used to demonstrate the deep-tank biological treatment process. The advantage of the deep-tank process is more efficient use of oxygen which is pumped in at the bottom of the column. This treatment method has potential application to many other industrial and municipal waste treatment problems.
(*g*) The process has been perfected on the 75 ft column and is now being scaled up to a 25 ft diameter by 36 ft high tank of the Inland Empire Paper Company.

052-09860-870-60

A COLUMN-FLOTATION PILOT FACILITY FOR SINGLE-CELL PROTEIN FROM POTATO WASTES

(*b*) State of Idaho.
(*c*) M. L. Jackson, Professor, Chemical Engineering.
(*d*) Experimental; applied research, M.S. thesis.
(*e*) This project is developing a semi-pilot scale fermentation facility to produce single-cell protein from potato processing wastes using a 75 ft column aerator.
(*g*) The work is nearing completion and a report will soon be available.

052-09861-870-10

PILOT PLANT WORK ON AMMONIA CONTROL: DWORSHAK NATIONAL FISH HATCHERY

(*b*) U.S. Army Corps of Engineers.
(*c*) A. T. Wallace, Professor, Civil Engineering.
(*d*) Experimental; design, M.S. thesis.
(*e*) Evaluate various schemes for water treatment in large fish hatcheries which reuse their rearing water.
(*g*) A pilot plant using a floating media for attachment of nitrifying bacteria has been developed.

052-09862-860-33

PHYSICAL AND DECISION-MAKING ALTERNATIVES FOR FLOW REGULATION AND USE OF SNAKE RIVER THROUGH HELLS CANYON

(*b*) OWRT.

(*c*) C. C. Warnick, Professor, Civil Engineering.
(*d*) Field study operation; M.S. thesis.
(*e*) A study of alternatives for use of water of the Snake River through the Hells Canyon area.
(*g*) An M.S. thesis has been completed which evaluates pump storage sites in the Hells Canyon region.

052-09863-110-54

LASER VELOCIMETER STUDIES OF MHD ENTRANCE FLOWS

(*b*) National Science Foundation.
(*c*) W. J. Thomson, Professor, Chemical Engineering.
(*d*) Experimental; applied research, Ph.D. dissertation.
(*e*) A theoretical/experimental study of the influence of a strong magnetic field on the fluid mechanic behavior of electrically conducting fluid. The studies include measurements of point velocities during both laminar and turbulent flow with a split beam, laser Doppler velocimeter.
(*g*) A Ph.D. dissertation will be completed in 1977.

052-09864-140-52

HEAT TRANSFER IN FLUIDIZED BEDS

(*b*) ERDA.
(*c*) W. J. Thomson, Professor, Chemical Engineering.
(*d*) Experimental; applied research, M.S. thesis.
(*e*) Direct comparisons of the heat transfer rates from immersed tubes to various sized fluidized beds equipped with different distribution plates and two sizes of particulates are being conducted.
(*g*) Results of this work may be used in various processes where heat transfer in fluidized beds is being used.

052-09865-370-470

RIVER MECHANICS MANUAL ADDENDUM

(*b*) Federal Highway Administration.
(*c*) F. J. Watts, Professor and Chairman, Civil Engineering.
(*d*) Operations.
(*e*) A manual is being prepared which will help highway engineers apply recently published river mechanics material in the analysis and design of river crossings and encroachments.
(*g*) A report will be completed in 1977.

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IIT RESEARCH INSTITUTE, Engineering Research Division, 10 West 35th Street, Chicago, Ill. 60616. Dr. K. E. McKee, Director.

053-10404-630-70

EVALUATION OF NOISE FROM HYDRAULIC PAVEMENT BREAKER

(*b*) Industrial.
(*c*) Dr. R. S. Norman, Riverbank Acoustical Laboratory.
(*d*) Experimental.
(*e*) Acoustic measurements were made on different hydraulically driven, pavement breakers. A free-field environment was used during actual breaking of concrete.
(*f*) Completed.
(*g*) Several noise sources were identified. Noise comparisons were made between pneumatic and hydraulic breakers.

053-10405-870-70

WIND TUNNEL MODELING OF PLANT MODERNIZATION

(*b*) Industrial.
(*c*) Dr. R. S. Norman, Dr. H. M. Nagib.
(*d*) Experimental evaluation.
(*e*) In order to predict odor pollution levels from a major plant expansion, comprehensive computer and wind tunnel modeling techniques were used. Using a scale model of the plant and surrounding buildings, different stack velocities, temperature ratios, and heights were evaluated as a function of wind conditions. Smoke visualization techniques were used to qualitatively study pollution concentrations in the nearby community. Parallel measurements of effluent concentration were made using heated stack gases as a scalar tracer.
(*g*) Minimum stack heights and gas velocities are being selected to reduce odor levels in the residential neighborhood.

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ILLINOIS STATE WATER SURVEY, Box 232, Urbana, Ill. 61801. William C. Ackermann, Chief. (A list of publications is available upon request from Illinois State Water Survey.)

054-09913-350-60

HYDRAULIC MODEL STUDY OF SPILLWAY FOR THE MIDDLE FORK VERMILION RIVER RESERVOIR

(*b*) Division of Water Resources, Illinois Department of Transportation.
(*c*) Mr. H. W. Humphreys.
(*d*) Experimental, design.
(*e*) Hydraulic model study was made of the service spillway and associated structures for the proposed Middle Fork Vermilion River Reservoir near Danville, Illinois. Study objectives were 1) test the preliminary design to identify the features where the hydraulic performance could be improved; 2) modify the features and test in the model; and 3) make recommendations for hydraulic design.
(*f*) Completed.
(*g*) Final report submitted to sponsor.

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UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN, Colleges of Agriculture and Engineering, Department of Agricultural Engineering, Urbana, Ill. 61801. Frank B. Lanham, Department Chairman.

055-08024-820-07

NITROGEN AS AN ENVIRONMENTAL QUALITY FACTOR–DETERMINING AND MODELING THE VARIOUS STEPS OF THE N CYCLE

(*b*) USDA-CSRS, Illinois; Rockefeller Foundation; Illinois Institute for Environmental Quality; U.S.-E.P.A.
(*c*) Dr. P. N. Walker.
(*d*) Field and laboratory investigation; basic research.
(*e*) See WRRC **9**, 5.0615.
(*g*) It has been found that 65 percent of rainfall falling on concrete feedlots runs off. Although a fertilizer benefit is possible through the effective use of this runoff water, this benefit is not large in terms of total area that can be adequately fertilized. For example, an 0.8 acre feedlot will fertilize about 11 acres in terms of the nitrogen requirement of corn. A major part of the nitrogen study was completed in 1975 with the following conclusions: (1) Livestock or human waste is the primary source of nitrates in shallow farmstead wells in Southern Illinois. (2) Livestock waste can be controlled by existing systems but at a relatively high cost. (3) Farm ponds polluted by runoff from livestock areas have low nitrate levels when compared to wells in the same area. Pollutants, including nitrogen, make pond water difficult to treat economically. Data has been collected for one growing season on the use of vegetative filters as a method to treat feedlot runoff prior to discharge. Initial observations are encouraging that this method is feasible, but this must be confirmed by further evaluation. A study is being conducted to determine the nutrient loss below the root zone of corn under sprinkler irrigation on a sandy soil. It has been found that manure releases nitrogen at a slower rate than chemical fertilizer or sludge. It has been found also that well fertilized corn removes water and nutrients from a deeper zone in the soil than corn grown with a low fertility.

(*h*) **Denitrification in Laboratory Sand Columns,** L. A. Davenport, W. D. Lembke, B. A. Jones, Jr., *Trans. ASAE* **18:1,** pp. 95–99, 105 (1975).
Planning Irrigation and Drainage Systems Using Retention and Extraction Limits, M. D. Campbell, W. D. Lembke, *Trans. ASAE* **18:3,** pp. 514-517 (1975).
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Performance of Livestock Feedlot Runoff Control Systems, E. C. Dickey, D. H. Vanderholm, *Ill. Res.* **18:1,** pp. 10-11 (1976).
Control of Runoff from Uncovered Swine Confinement Facilities, D. H. Vanderholm, E. C. Dickey, *Proc. Intl. Pig Veterinary Soc. Cong.,* Ames, Iowa, (1976).

055-08681-810-07

RUNOFF FROM SMALL AGRICULTURAL AREAS IN ILLINOIS.

(*b*) U.S. Department of Agriculture.
(*c*) Dr. J. Kent Mitchell.
(*e*) See **WRRC 9,** 2.0497.
(*g*) The 1974 rainfall-runoff data showed considerable periods of above normal rainfall and runoff. The total rainfall for 1974 was 47.40 inches which was approximately 10 percent higher than the 43.59 inches recorded at the Urbana station and 10.10 inches greater than the long-term average collected at the watersheds. Most of the above normal rainfall occurred in May (8.10 inches), June (8.55 inches) and August (6.56 inches). May rainfall events were not exceptional but there were 16 days with rainfall. There were 15 days of rainfall in June with only one large event of 4.71 inches. August rainfall was in three events of 1.60, 3.43, and 0.74 inches. Runoff events were also quite numerous and exceptionally high for these stations with 6.39 inches of runoff recorded from Watershed A1. The greatest runoff amounts occurred in June with 3.60 inches recorded, all occurring from June 21 to June 23. The maximum runoff rate for this storm was 7 cfs (.87 iph). There was rainfall of 4.71 inches during that period with two rainfall events totalling 1.52 inches in the 7 days prior to the June 21-23 event. The watershed was entirely fallow during this period. The history, literature, data collection methods, watershed characteristics, and the rainfall and runoff data is being summarized for 25 years of operation.

055-08682-820-00

HYDRAULIC AND HYDROLOGIC MODELS OF COMPONENTS OF SOIL AND WATER CONTROL SYSTEMS

(*c*) Dr. W. D. Lembke.
(*e*) See **WRRC 9,** 2.0498.
(*g*) At 79 farm installations in Illinois, the deflection of corrugated plastic tubing was measured after the tubing had been installed for a minimum of 18 months. Commercial tubing sizes varied in diameter from 127 mm (5 to 8 in.). The amount of deflection that occurred was related to pipe stiffness; groove angle; soil type; duration; cover; trench width; stretch; and installation technique. A field study was initiated with the cooperation of Agricultural Engineering and Agronomy Departments during the growing season of 1976 to compare sprinkler irrigation, surface irrigation and no irrigation of corn on a claypan soil using two replications. Yield averages were 139, 152 and 36 bushels per acre, respectively. It was evident that with the water stress on corn plants that occurred during 1976, irrigation could be a profitable venture depending on the water supply cost.
(*h*) **Micro-Relief Surface Depression Storage: Analysis of Models to Describe the Depth Storage Function,** J. K. Mitchell, B. A. Jones, Jr., *Water Reso. Bul.* **12:6,** pp. 1205-1222 (1976).
Deflectometer Profiles Drain Tubing, P. N. Walker, C. J. W. Drablos, *Agricultural Engrg.* **57:6,** pp. 44-45 (1976).

UNIVERSITY OF ILLINOIS, Hydrosystems Laboratory, Department of Civil Engineering, Urbana, Ill. 61801. Professor V. T. Chow.

056-07339-810-33

STOCHASTIC ANALYSIS OF HYDROLOGIC SYSTEMS

(*b*) Office of Water Resources Research.
(*d*) Theoretical; applied research.
(*e*) Develop a practical procedure by which the stochastic behavior of a hydrologic system can be adequately simulated. In the study a watershed is treated as the stochastic hydrologic system whose components are simulated by time series models. Emphasis is given to application of the procedure to the planning of rural and urban watersheds in Illinois.
(*h*) **Analysis of Residual Hydrologic Stochastic Processes,** S. J. Kareliotis, V. T. Chow, *J. Hydrology* **15,** 2, Feb. 1972, pp. 113-130.
Theory of Stochastic Modeling of Watershed Systems, V. T. Chow, T. Prasad, *J. Hydrology* **15,** 4, Apr. 1972, pp. 261-284.
Analysis of Multiple-Input Stochastic Hydrologic Systems, *Res. Rept. No. 67,* Water Resources Center, Univ. Ill. at Urbana-Champaign, Urbana, Ill., July 1973, 66 pages.
A Scheme for Stochastic State Variable Water Resources Systems Optimization, V. T. Chow, D. H. Kim, D. R. Maidment, T. A. Ula, Water Resources Center, *Research Rept. No. 105,* Univ. of Ill., Urbana-Champaign, Oct. 1975, 102 pages.

056-07340-310-00

EVALUATION OF HYDROLOGIC RISKS

(*b*) University of Illinois and Kanazawa University.
(*c*) Professors V. T. Chow, N. Takase.
(*d*) Theoretical; applied research.
(*e*) Hydrologic extremes such as floods and low flows are treated as independent random variables. Accordingly, probabilistic models are derived for two approaches of adopting hydrologic extremes as design criteria in water resources project planning. One approach is to use the hydrologic event of a given recurrence interval, and the other is to use the extreme event observed in the record. The models are verified agreeably by the flood data of ten Illinois rivers. Both models give essentially the same results when the period of design is less than one-tenth of the recurrence interval and the length of record. Also, by the Monte Carlo method, synthetic hydrologic extremes are generated by a time-series model for use in water resources systems analysis.
(*h*) **Design Criteria for Hydrologic Extremes,** V. T. Chow, N. Takase, *J. Hyd. Div., Proc. ASCE* **103,** HY4, pp. 425-436, Apr. 1977.

056-08030-860-00

OPTIMAL OPERATION OF RESERVOIRS

(*d*) Theoretical; applied research.
(*e*) Operations research techniques are used to optimize the operation of a system of reservoirs. The procedure so developed is used to determine operating policies for exist-

ing reservoir systems or for potential system designs in connection with simulation studies. An actual flood control system located in the Upper Wabash River Basin in Indiana is used as an illustrative example.

(*h*) **Multireservoir Optimization Model,** J. S. Windsor, V. T. Chow, *J. Hydraul. Div., ASCE* **98,** HY10, Oct. 1972, pp. 1827-1845.
Multireservoir Optimization Model, J. S. Windsor, V. T. Chow, *Trans. ASCE* **138,** 1973, pp. 532-533.
On Multipurpose Storage Pumping Schemes, V. T. Chow, *Proc. Intl. Symp. Multipurpose Storage Pumping Schemes, Centro de Estudios Hidrograficos, Comite Español de la* IWRA, pp. 19-25, Nov. 1974.

056-08031-800-33

ADVANCED METHODOLOGIES FOR WATER RESOURCES PLANNING–PHASE II

(*b*) Office of Water Resources Research.
(*d*) Theoretical; applied research.
(*e*) Refine the new methodologies that have been developed in Phase I of the research program, to develop additional new water resources planning tools, and to perform sensitivity tests for proposed or existing water resources projects by means of the new planning tools so developed in order to examine the system responses due to hydrologic, economic urban and other factors affecting water resources problems. The proposed research proceeds in two stages. The first stage is to refine the DDDP technique for variable width of its *corridor* and for its conjunctive use with the successive dynamic programming technique in order to achieve maximum efficiency of utilization. The second stage is devoted to investigate new water resources problems such as water quality control and urban water development, and then to apply the new DDDP and MLOM techniques to these models.
During the past two years, mathematical models for evaluating computer time and memory were developed for dynamic programming and discrete differential dynamic programming in water resources systems analysis. The models are: Execution time $= T_a MN\Pi Q_i \Pi P_j$, and Memory $= 2\Pi Q_i + ND\Pi Q_i$ with $i = 1,..., S$ and $j = 1,...,D$; where T_a is the time for unit operation; M, the number of optimization iterations; N, the number of stages; and Q_i and P_i, numbers of feasible values that state variable i and decision variable j, respectively, can take in each iteration or in optimization. Problems of operations of reservoir networks and design of storm sewer systems and aqueducts were used to verify the models.
(*h*) **Application of DDDP in Water Resources Planning,** V. T. Chow, G. Cortes-Rivera, Water Resources Center, *UILU-WRC-74-0078, Res. Rept. No. 78,* Univ. Ill. at Urbana-Champaign, Urbana, Ill., 89 pages, Jan. 1974.
Model for Farm Irrigation in Humid Areas, J. S. Windsor, V. T. Chow. *Trans. ASCE* **137,** 1972, pp. 687-688.
Computer Memory Requirements for DP and DDDP in Water Resources Systems Analysis, D. R. Maidment, V. T. Chow, G. W. Tauxe, *Trans. Amer. Geophysical Union* **55,** 4, p. 249, Apr. 1974.
Computer Time Requirements for DP and DDDP in Water Resources Systems Analysis, V. T. Chow, D. R. Maidment, G. W. Tauxe, *Trans. Amer. Geophysical Union* **55,** 4, p. 249, Apr. 1974.
Water Resources Systems Planning, V. T. Chow, *Proc. Modern Engrg. and Technology Seminar* **8,** Water Resources Session, Chinese Institute of Engineers, 1974.
Computer Time and Memory Requirements for DP and DDDP in Water Resources Systems Analysis, V. T. Chow, D. R. Maidment, G. W. Tauxe, *Water Resources Research* **11,** 5, pp. 621-628, Oct. 1975.

056-08032-810-00

MODELING OF HYDROLOGIC SYSTEMS

(*d*) Theoretical; applied research.
(*e*) A lumped, deterministic, nonlinear mathematical model proposed for the simulation of hydrologic systems is developed from expansion of a general storage function of input and output in Taylor's series about a steady state. The model recommended for practical application is based on the system model in the form of a third-order differential equation, the coefficients of which are considered as functions of the peak discharge of direct runoff. In the analysis of the model, watershed is taken as the hydrologic system. Nine watersheds with more than 70 major and minor storms were used in the analysis and verification of the recommended model. The results indicate a very satisfactory simulation of watershed hydrologic systems by the model.
(*h*) **Hydrologic Modeling–The Seventh John R. Freeman Memorial Lecture,** *Proc. Boston Soc. of Civil Engrg.* **60,** 5, Jan. 1972, pp. 1-27.
Discussion on General Hydrologic System Model, V. T. Chow, V. C. Kulandaiswamy, *J. Hydraul. Div., ASCE* **98,** HY10, Oct. 1972, pp. 1873-1874.
General Hydrologic System Model, V. T. Chow, V. C. Kulandaiswamy, *Trans. ASCE* **137,** 1972, p. 704.
An Introduction to Systems Analysis of Hydrological Problems, V. T. Chow, *Proc. 2nd. Intl. Sem. for Hydrology Professors,* Aug. 2-14, 1970, Utah Water Research Lab., Utah State Univ. 1973, pp. 15-41.
Systems Analysis for Hydrologic Input to Water Resources Management, *Proc. Symp. System Analysis Applied to Water Resources Development,* Mar del Plata, Argentina, Argentina Society of Water Resources System, Intl. Water Resources Assoc., Intl. Federation for Automatic Control, *CONFAGUA/C-419,* Mar. 1977, 14 pages.

056-08709-310-33

FLOOD CONTROL PROJECT EXPANSION MODELING

(*b*) Office of Water Resources Research.
(*d*) Applied research.
(*e*) A mathematical model is developed for a flood control project planning process which considers the combined use of structural and nonstructural alternatives for flood damage reduction. The model is solved by parametric linear programming and discrete differential dynamic programming. It is then applied to an actual project on the Embarras River, Illinois, proposed by the U.S. Corps of Engineers.

056-08710-810-36

METHODS FOR DETERMINING URBAN STORM RUNOFF

(*b*) U.S. Environmental Protection Agency.
(*c*) Professors V. T. Chow and B. C. Yen.
(*e*) An investigation has been made to develop a method of depth-duration-frequency analysis for rainfall events having short return period; develop a new high-accuracy urban stormwater runoff determination method; and compare and evaluate the following eight selected urban storm runoff prediction methods: the rational method, unit hydrograph method, Chicago hydrograph method, British Transport and Road Research Laboratory method, University of Cincinnati Urban Runoff method, Dorsch method, EPA Storm Water Management Model, and Illinois Storm Runoff method. The comparison and evaluation was done by using four recorded hyetographs for the Oakdale Avenue drainage basin in Chicago to produce the predicted hydrographs by the methods; the results were compared with recorded hydrographs.
(*h*) **Urban Stormwater Runoff: Determination of Volumes and Flowrates,** V. T. Chow, B. C. Yen, Municipal Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, *EPA-600/2-76-116,* Environmental Protection Technology Series, May 1976, 239 pages.
Prediction Model for Urban Storm Runoff, A. O. Akan, B. C. Yen, V. T. Chow, *Trans. Amer. Geophysical Union* **57,** 4, p. 247, Apr. 1976.

Prediction of Urban Storm Runoff, B. C. Yen, A. O. Akan, V. T. Chow, A. S. Sevuk, in *Utility of Urban Runoff Modeling, ASCE Urban Water Resources Research Program, Tech. Memo. No. 31*, pp. 108-117, July 1976.

056-08711-810-54

HYDRODYNAMIC MODELING OF FLOOD FLOWS

(*b*) National Science Foundation.
(*c*) Professors V. T. Chow and B. C. Yen.
(*d*) Experimental and analytical.
(*e*) Develop an improved advanced mathematical simulation model for analyses of flood flows. The most appropriate forms of the St. Venant equations and their various levels of approximations for flood routing in streams as well as on watershed surfaces have been investigated. These partial differential equations have been solved numerically using a four-point implicit scheme. The model will be further tested and the results will be useful in many engineering and environmental problems related to flood flows.
(*h*) **A Laboratory Watershed Experimentation System,** V. T. Chow, B. C. Yen, Civil Engrg. Studies, *Hydraulic Engrg. Ser. No. 27*, Univ. Ill., Aug. 1974, 200 pages.
The Evaluation of a Hydrodynamic Watershed Model (IHW Model IV), C. H. Hsie, V. T. Chow, B. C. Yen, Civil Engrg. Studies, *Hydraulic Engrg. Series No. 28*, Univ. Ill., Aug. 1974, 143 pages.
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The Illinois Hydrodynamic Watershed Model III (IHW Model II), V. T. Chow, A Ben-Zvi, *Civil Engrg. Studies, Hydraulic Engrg. Ser. No. 26*, Univ. Ill., Sept. 1973, 47 pages.
Hydrodynamic Modeling of Two-Dimensional Watershed Flow, *J. Hydraul. Div., ASCE* **99,** HY11, pp. 2023-2040, Nov. 1973.
A Constant Discharge Siphon for Flow Measurement and Control, B. C. Yen, V. T. Chow, *Proc. Koblenz Symp.* **1,** W. Germany, UNESCO-WMO-IASH, pp. 444-452, 1973.
Role of WES in the Development of Hydrodynamic Watershed Models, V. T. Chow, Intl. Assoc. of Hydrological Sciences, *IAHS-AISH Publication No. 101*, pp. 775-783, 1974.

056-10092-810-47

FEASIBILITY STUDY ON RESEARCH OF LOCAL DESIGN STORMS

(*b*) U.S. Federal Highway Administration.
(*c*) Professors V. T. Chow and B. C. Yen.
(*d*) Analytical, applied research.
(*e*) Investigate the feasibility of a comprehensive study on nation-wide determination of the local design rainstorm hyetographs for urban highway storm drainage facilities. Conditional probabilities will be used in the analyses.

056-10093-810-36

STORM RUNOFF IN STEEP URBAN AREAS

(*b*) U.S. Environmental Protection Agency.
(*c*) Professors V. T. Chow and B. C. Yen.
(*d*) Analytical, applied research.
(*e*) In the previous part of this project a new computer based urban storm runoff quantity and quality determination method was developed and this method was compared with seven other methods (rational, unit hydrograph, Chicago hydrograph, British TRRL, Univ. of Cincinnati, Dorsch Hydrograph Volume, and EPA Storm Water Management Model). In this part of the research efforts are concentrated on storm runoff in steep urban areas. Reasons for the failure or inaccuracy of the existing methods to predict storm runoff on steep slopes are investigated and alternative method is suggested.

056-10094-810-33

DECISION ANALYSIS FOR THE DESIGN OF WATER RESOURCES SYSTEMS UNDER HYDROLOGIC UNCERTAINTY

(*b*) Office of Water Resources Research.
(*d*) Analytical, applied research.
(*e*) This study deals with the analysis of the uncertainty in hydrologic time series which consist of model uncertainty and parameter uncertainty, and the development of a procedure which explicitly accounts for the parameter uncertainty in the decision analysis for the design of water resources systems. Various models proposed for streamflow simulation are reviewed, including Markov models and the fractional Gaussian noise process for streamflow modeling. A new model, a second-order autoregressive model with a data-based transformation, is developed. Estimation of and inferences about the model parameters are made by employing both the maximum likelihood method and the Bayesian approach. A design example indicates that the decision procedure which ignores the parameter uncertainty could lead to suboptimal design.

056-10095-300-33

MONTHLY STREAMFLOW GENERATION WITH EMPHASIS ON PARAMETER UNCERTAINTIES

(*b*) Office of Water Resources Technology.
(*d*) Analytical, applied research.
(*e*) This study considers a realistic approach to generate streamflows that will recognize and account for the sampling errors inherent in the estimates of model parameters. Two verions of a linear model of generation are considered. One is the conventional case in which errors are assumed to be uncorrelated; the other is a more general case in which errors are assumed to be generated by a stationary Markov process. The two cases are compared through an application in order to access any significant changes in the generated streamflows. In the study, the algorithms for the two cases are developed for generation of monthly streamflow sequences. Such generated streamflows are useful as input to the planning and design of water resources systems.

056-10096-810-00

HYDROLOGIC MODELING FOR URBAN DRAINAGE DESIGN

(*d*) Analytical, applied research.
(*e*) This study involves the development of a hydrologic model, which may be deterministic or stochastic, lumped or distributed, for practical use in urban drainage design. Various hydrologic models that are now available for such purposes have been reviwed. It was found that a state variable model coupled with stochastic input may be developed with great flexibility for the urban drainage situation.

056-10097-800-33

OPTIMIZATION OF WATER RESOURCES SYSTEMS

(*b*) Office of Water Resources Technology.
(*d*) Analytical, applied research.
(*e*) The physical dynamics of both the controllable and uncontrollable parts of a water resource system are formulated using the state variable approach. The model so formulated can be used by itself for the simulation of the behavior of the system. As such, the state variable ap-

proach represents a generalized framework within which many different kinds of existing system models may be expressed and combined. This model is then used within optimizational procedures so that the optimal policy for the controllable part of the system may be found. A methodology is developed in which a stochastic state variable model of the system may be incorporated within a stochastic dynamic programming procedure to find the optimal closed loop policy for the operation of the system.

(*h*) **A New Approach to Urban Water Resources Systems Optimization,** D. R. Maidment, V. T. Chow, in *The Environment of Human Settlements, Human Well-Being in Cities 1*, Proc. Conf. held in Brussels, Belgium, Pergamon Press, pp. 249-259, Apr. 1976.

056-10098-310-61

FLOOD PLAIN MANAGEMENT THROUGH OPTIMAL ALLOCATION OF LAND USES

(*b*) University of Illinois, Water Resources Center.
(*c*) Professors L. D. Hopkins, E. D. Brill, Jr., J. C. Liebman, H. G. Wenzel.
(*e*) Develop means for identifying and achieving more nearly optimal patterns of land use with respect to flooding. The immediate objective is to formulate a land allocation model involving economic theories of externalities and land-use. The Hickory Creek watershed in northeastern Illinois will serve as a study area for the development of an initial model. A hydrologic simulation model will be developed for the purpose of assessing flood damages as a function of land use. This will be incorporated in a land-use optimization model based on dynamic programming.

056-10099-300-00

TRANSPORT OF EFFLUENTS IN RIVERS

(*c*) Professor E. R. Holley.
(*e*) Evaluation of potential effects of an effluent discharged into a river includes analyzing the effluent transport in the river. Similar analyses are needed for the effects of accidental spills of hazardous substances. Depending on the type of effluent or spill, the necessary predictions can involve analysis of transverse and/or longitudinal mixing, both of which are being studied analytically. For transverse mixing, the diffusion equation will be solved taking into account both natural changes in width, depth, and transverse diffusion coefficient for the river and the distance between tributary streams. For longitudinal mixing, the natural stream geomtry, including the irregularities in boundary geometry, will be included in a reevaluation of the initial-convective period duration and the longitudinal dispersion coefficient. Results will be comapred with available data.
(*h*) **Stratified Flow in Great Salt Lake Culvert,** E. R. Holley, *Inst. Eng. Australia, Qld. Div.* **6**, 4, pp. 1-16, 1975.

056-10100-050-00

ENTRAINMENT OF TURBULENT JETS DISCHARGED INTO FLOWING AMBIENT FLUIDS

(*c*) Professor W. H. C. Maxwell.
(*d*) Theoretical, basic research.
(*e*) Develop techniques for evaluation of entrainment coefficients when there is a horizontal surface discharge of heated water from a rectangular open channel into a flowing river. Entrainment is assumed proportional to the vector difference between the centerline jet velocity and the free-stream velocity. A set of first-order, nonlinear, ordinary differential equations is developed, together with a numerical scheme for solving these equations. Empirical coefficients are determined using available data.

056-10101-050-00

SUBMERGED JETS

(*c*) Professor W. H. C. Maxwell.
(*d*) Theoretical, applied research.
(*e*) Sewage and thermal wastes are commonly disposed into rivers, lakes, and oceans. A single outfall submerged at some depth below the surface of the receiving water is a popular disposal technique. Prediction of the resulting dilutions and the extent of the affected area is of primary importance for design and operation of such disposal schemes. This purpose can be achieved by deriving a mathematical model based on the conservation of the jet mass and momentum fluxes. In a stagnant homogeneous ambient fluid, the conservation considerations, when coupled with a suitable entrainment function, yield a system of six simultaneous differential equations. Such a system may be solved numerically for the range of prototype initial and boundary conditions. The solutions are compared with the available experimental data to verify the model performance.

056-10102-290-00

BUBBLE SCREENS

(*c*) Professor W. H. C. Maxwell.
(*d*) Theoretical, applied research.
(*e*) Air bubbles have long been used as pneumatic breakwaters, as ice deterrents in waterways, to control density currents and shoaling in estuaries, and to prevent stratification and promote mixing in lakes and reservoirs. Nevertheless, little is known about the design principles for these applications although field data are available for specific developments. A mathematical model is being developed to describe the flow field induced by a single nozzle discharging air into a stagnant body of water, taking into account bubble compressibility. Solutions are sought numerically to obtain the induced flow field for a practical range of submergences and air flows.

056-10103-870-00

DIFFUSER OUTLETS

(*c*) Professor W. H. C. Maxwell.
(*d*) Theoretical, applied research.
(*e*) Compare different numerical models for diffusers and outlets and their predictions of the mixing of the effluent with the ambient fluid with available field and experimental data. Various techniques for increasing the mixing are being considered, together with methods of adapting the available mathematical models to incorporate these techniques.

056-10104-870-33

CONTROL OF MIXING AT HEATED WATER OUTLETS

(*b*) Office of Water Research and Technology.
(*c*) Professor W. H. C. Maxwell.
(*d*) Analytical, applied research.
(*e*) A shallow submerged horizontal water discharge deflects toward the free surface. For a heated discharge the flow pattern is complicated by buoyancy effects. Wing-walls limiting lateral entrainment result in a roller vortex over the discharge outlet. Its effect is so overwhelming as to mask any effect of density difference. By regulating flow over the wing-wall crests the flow pattern may be controlled. This investigation provides laboratory data including velocity and temperature traverses showing how flow over the wing-walls and variations in the length of the wing-walls affect the flow pattern.

056-10105-060-33

MECHANICS OF HEATED SURFACE DISCHARGES TO RIVERS–PHASE II

(*b*) Office of Water Research and Technology.
(*c*) Professors E. R. Holley and W. H. C. Maxwell.
(*d*) Theoretical, applied research.
(*e*) Thermal power plants frequently discharge their waste heat to natural water bodies as heated water. In this connection, this research is conducting analytical and experimental studies of both surface and submerged heated discharge. For the surface discharges, a three-dimensional

analytical representation has been developed to account for strong ambient currents, jet curvature, unequal lateral entrainment on the sides of the jet, and asymmetry of the velocity and temperature profiles. Laboratory experiments are being conducted to check the analytical model. Also, the effects of a vertical cross-flow induced by an air bubble screen are being studied experimentally for a submerged discharge. A preliminary mathematical model has been developed and will be refined using data obtained on velocity and temperature profiles.

(*h*) **Study of Stratified Overflows and Underflows,** W. H. C. Maxwell, E. R. Holley, C. Y. Lin, S. Tekeli, *Res. Rept. No. 98,* Univ. of Ill. Water Resources Center, 1975.

056-10106-810-33

RISK-BASED HYDRAULIC AND HYDROLOGIC DESIGN

(*b*) Office of Water Research and Technology.
(*c*) Professors B. C. Hen and W. H. C. Tang.
(*d*) Analytical, applied research.
(*e*) The major purpose of this research is to develop a new method for hydraulic and hydrologic design of engineering projects avoiding the conventionally used and arbitrarily chosen return period and safety factor. The new method is based on conditional probability theory considering various uncertainties in an engineering project, including uncertainties on rainfall, runoff, and other hydrologic aspects, on formula reliability, channel, or pipe roughness and other hydraulic factors, on structural variables, and on material and construction reliabilities. The method has been applied successfully to storm sewer design.
(*h*) **Risk-Based Design of Storm Sewers,** B. C. Yen, *Rept. Hydraulic Research Station,* Wallingford, England, 1975.

056-10107-870-00

HYDRAULICS OF STORM SEWERS

(*c*) Professor B. C. Yen.
(*d*) Analytical, applied research.
(*e*) This research covers a broad scope consisting of many aspects of hydraulics related to design and operation of storm sewers. Reliabilities of various routing methods for the unsteady flow in a single sewer as well as sewer networks are investigated, with particular emphasis on the effect of the junctions. The influence of on-line retention, surcharge, and roughness factors are all considered. The results are particularly useful for improvement of sewer designs.
(*h*) **Design of Sewer Networks,** B. C. Yen, A. S. Sevuk, *J. Environ. Eng. Div., Proc. ASCE* **101,** EE4, pp. 535-553, Apr. 1975.

056-10108-870-33

ADVANCE METHODOLOGIES FOR DESIGN OF STORM SEWER SYSTEMS

(*b*) Office of Water Research and Technology.
(*c*) Professors B. C. Yen, H. G. Wenzel and W. H. C. Tang.
(*d*) Analytical, applied research.
(*e*) Develop an improved methodology for design strategies and procedure for storm sewer systems on the basis of an integrated consideration of hydraulics, risk analysis, cost-damage-benefit relationships, optimization, and system analysis. The developed method provides a rational means for the determination of the size and slope of sewer pipes on the basis of minimum total cost for the entire sewer system. A discrete differential dynamic programming technique is used in the optimization. The model also has several simpler versions, each suitable for certain special conditions.
(*h*) **Worth of Data for Optimal Design of Storm Sewers,** L. W. Mays, B. C. Yen, W. H. Tang, *Proc. 16th Congr. Intl. Assoc. for Hydraulic Res.* **4,** pp. 34-42, 1975.

056-10109-870-33

RISK-BASED METHODOLOGY FOR COST-EFFECTIVE DESIGN OF STORM SEWER SYSTEMS–PHASE II

(*b*) Office of Water Research and Technology.
(*c*) Professors H. G. Wenzel, B. C. Yen and W. H. C. Tang.
(*d*) Analytical, applied research.
(*e*) The initial work of this project was concerned with the development of a storm sewer design computer model in which decisions on pipe sizes and elevation were made for a specific layout on the basis of minimum expected costs. This study extends this work in several areas. Current efforts are to incorporate a hydrologic model to determine inflow hydrographs. Also, refinements in the risk model, i.e., the procedure for including uncertainties, as well as an improved method of including damage costs in the design are being investigated.
(*h*) **Optimal Cost Design of Branched Sewer Systems,** L. W. Mays, B. C. Yen, *Water Resources Research* **11,** 1, pp. 37-47, Jan. 1975.

056-10110-200-00

FUNDAMENTAL STUDY OF THE FORMULATION OF OPEN-CHANNEL FLOW EQUATIONS

(*b*) University of Illinois; University of Karlsruhe.
(*c*) Professor B. C. Yen.
(*d*) Theoretical; basic research.
(*e*) Equations of continuity, momentum, and energy for a point are integrated over a cross section to formulate the unified one-dimensional equations for spatially varied, unsteady, turbulent flow of homogeneous or nonhomogeneous fluid in open channels of arbitrary cross-sectional shape and alignment. Both natural coordinate systems and gravity-oriented coordinate systems are considered. Simplified equations for special cases are derived, and assumptions of commonly used open-channel flow equations are examined.
(*h*) **Backwater Surface Profile Computer Program,** A. K. Rostogi, W. Rodi, B. C. Yen, *Sonderforschungesbereich* **80,** *Publ. No. SFB/80/T/48,* Univ. of Karlsruhe, W. Germany, 1975.
Further Study on Open-Channel Flow Equations, B. C. Yen, *Sonderforschungesbereich* **80,** *Publ. No. SFB/80/T/49,* Univ. of Karlsruhe, W. Germany, 1975.
Open Channel Roughness–A Review of Manning's Roughness Factor, B. C. Yen, *Sonderforschungesbereich* **80,** *Publ. No. SFB/80/T/57,* Univ. of Karlsruhe, W. Germany, 1975.
Spiral Motion and Erosion in Meanders, B. C. Yen, *Proc. 16th Congr. Intl. Assoc. for Hydraulic Res.* **2,** pp. 338-346, 1975.

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UNIVERSITY OF ILLINOIS, Fluid Mechanics and Hydraulics Laboratory, Department of Theoretical and Applied Mechanics, Urbana, Ill. 61801. Professor R. T. Shield, Department Head. Professor J. M. Robertson, Area Coordinator for Fluids.

057-04143-270-60

APPLICATION OF PRINCIPLES OF FLUID MECHANICS TO ANALYSES OF PATHOLOGICAL CHANGES IN THE CEREBRAL CIRCULATION

(*b*) Illinois Department of Mental Health.
(*c*) Professor M. E. Clark, Talbot Laboratory.
(*d*) Computational, applied research, Ph.D. thesis.
(*e*) Project concerns fluid mechanic aspects of blood circulation in the brain and with factors which control this circulation in the brain and both for normal and diseased states. One-dimensional timewise development of flow and pressure are calculated on finite difference basis using improved dissipation terms and viscoelastic vessel wall.

057-05778-030-00

BODY FLOWS AT LOW REYNOLDS NUMBERS

(*c*) Professor J. M. Robertson, Talbot Laboratory.
(*d*) Basic analytical and experimental research.

(*e*) Except for flat plate, analytical flow and drag relations are available only in the creeping motion and boundary layer regimes. Experimental data is available only for a few other bodies in the intermediate (Navier-Stokes) range. Objective of study is to help fill this gap.
(*f*) Suspended.

057-07351-010-00

TURBULENT BOUNDARY LAYER FLOW ON FLAT PLATE

(*c*) Professor J. M. Robertson, Talbot Laboratory.
(*d*) Basic research; experimental and review of literature.
(*e*) Refurbishing of theory for layer, assessment of transition occurrences in terms of leading edge, stream turbulence level and roughness or trips; a second phase concerns effect of high stream turbulence level on a turbulent layer. Current work concerns leading edge study-effect of nose curvature on laminar transition vs separation occurrences and virtual origin of turbulent layer.

057-07352-120-00

FORCES ON BODIES IN NON-NEWTONIAN FLUIDS

(*c*) Professor J. M. Robertson, Talbot Laboratory.
(*d*) Basic research.
(*e*) Nature of body-force relations (particularly drag) for bodies in relative motion with fluids such as Bingham plastics. Experiments have been carried out with clay-water mixtures (and on their viscometry) and are planned for other fluids. Analytical work on extending theoretical formulations.
(*f*) Suspended.
(*g*) Numerical solution for viscoplastic laminar boundary layer on flat plate gives drag results close to experimental ones.
(*h*) **Forces on Bodies in Bingham Fluids,** H. Pazwash, J. M. Robertson, *J. Hydraul. Res.* **13,** pp. 35-55, 1975.
Couette Viscometry of Clay-Water Mixtures as Bingham Fluids, H. Pazwash, J. M. Robertson, *Iranian J. Science and Technology* **4,** pp. 107-14, 1976.

057-07353-630-70

NOISE PRODUCTION IN FLUID-POWER SYSTEMS

(*b*) Sundstrand Aviation.
(*c*) Professor J. M. Robertson, Talbot Laboratory.
(*d*) Basic research, analytical in nature with experiments planned.
(*e*) The manner of noise generation by pressure transients in the cylinders of positive-displacement pumps is being studied via analysis and analog experiments (water table) of wave motions.
(*f*) Discontinued.

057-07355-000-88

NUMERICAL ANALYSIS OF LAMINAR OSCILLATORY NAVIER-STOKES FLOWS PAST TWO-DIMENSIONAL AND AXISYMMETRIC CONDUIT NON-UNIFORMITIES

(*b*) National Science Foundation.
(*c*) Professor M. E. Clark, Talbot Laboratory.
(*d*) Theoretical and experimental research.
(*e*) Fluid dynamic occurrences in simple conduits for flows through various types of geometric barriers are being theoretically and experimentally correlated for comparison with hemodynamic occurrences in similar physiological situations. This research attempts to develop the analysis by finite difference solution of the appropriate Navier-Stokes equations for pressure, shear and vorticity. A transform is being exploited to treat irregular fixed and moving walls. Bends, bifurcations and valves are being modeled two-dimensionally.
(*g*) The simple transform has been found to be extremely useful and general in a myriad of applications.
(*h*) **Development and Demise of Secondary Flows in Unsteady Disturbed Flow,** L. C. Chang, M. E. Clark, *Proc. 28th Ann. Conf. on Eng. in Med. and Biol.* **17,** 275, 1975.
Analytical Approximation of Pulsatile Flow in Wavy Conduits, L. C. Cheng, M. E. Clark, *Proc. Canadian Conf. on Appl. Mech.*, pp. 621-622, 1975.
Effect of Channel Constriction on Oscillatory Flow in Plane Wavy Conduits, L. C. Cheng, M. E. Clark, W. C. Peng, *Proc. ASME 1975 Biomech. Symp. AMD* **10,** pp. 31-34, 1975.
Numerical Analysis of Unsteady Viscous Flow in Nonuniform Channels, M. E. Clark, J. M. Robertson, L. C. Cheng, *Proc. 29th Ann. Conf. on Eng. in Med. and Biol.* **18,** 334, 1976.
Viscous Flow Around a Cylinder in a Plane Conduit, L. C. Cheng, M. E. Clark, J. M. Robertson, *Developments in Mechanics* **8,** Univ. of Illinois at Chicago Circle, pp. 215-217, 1977.

057-08034-110-54

LIQUID-METAL CHANNEL FLOWS WITH STRONG MAGNETIC FIELDS

(*b*) National Science Foundation.
(*c*) Professor J. S. Walker, Talbot Laboratory.
(*d*) Theoretical.
(*e*) Project involves a large number of separate but closely related studies of three-dimensional liquid-metal magnetohydrodynamic (MHD) flows in the presence of strong applied magnetic fields. An extensive study of flows through rectangular and circular expansions and contractions has recently been completed. Currently active studies of liquid-metal MHD flows include periodic and solitary compressive waves, variable-depth open-channel flow, effects of temperature-dependent physical properties, duct flows in non-uniform fields and analysis of low-frequency rectangular A.C. induction pumps.
(*h*) **Uniform Open Channel Liquid Metal Flows with Transverse Magnetic Fields,** J. S. Walker, *Dev. in Mech., Proc. 14th Midwestern Mech. Conf.* **8,** pp. 421-436, 1975.
Entry Lengths for Circular and Rectangular Ducts in Strong Magnetic Fields, J. S. Walker, G. S. S. Ludford, *Magnitnaya Gidrodinamika (in Russian)* **1,** pp. 75-78, 1975.
MHD Flow in Circular Expansions with Thin Conducting Walls, J. S. Walker, G. S. Ludford, *Int. J. Eng. Sci.* **13,** pp. 261-269, 1975.
Open Channel MHD Flows, J. S. Walker, *MHD Flows and Turbulence*, ed. H. Branover. New York: Wiley, pp. 41-8.
Compression Waves in MHD Duct Flows, J. S. Walker, *MHD Flows and Turbulence*, ed. H. Branover. New York: Wiley, pp. 33-9.
On Establishing Fully Developed Duct Flow in Strong Magnetic Fields, J. S. Walker, G. S. S. Ludford, *MHD Flows and Turbulence*, ed. H. Branover. New York: Wiley, pp. 7-15.
Periodic Fluid Transients in Rectangular Ducts witn Transverse Magnetic Fields, II, J. S. Walker, *Zeitschrift for angewandte Matematik and Physik* **27,** pp. 71-82.
Duct Flows in Strong Magnetic Fields, J. S. Walker, G. S. S. Ludford, *Recent Advances in Engrg. Science* **6,** pp. 329-35.

057-08035-130-00

FLUID CONVEYANCE OF PARTICLES IN VERTICAL PIPES

(*c*) Professor J. M. Robertson, Talbot Laboratory.
(*d*) Basic research; student project.
(*f*) Discontinued.

057-09036-210-52

WATERHAMMER WAVES IN CURVED PIPES

(*b*) Argonne National Laboratory.
(*c*) Professor J. W. Phillips, Talbot Laboratory.
(*d*) Theoretical and experimental.

(*e*) Study treats the effects of tube curvature on waterhammer waves propagating along helical tubes or through tube bends. The results will be applied to disaster predictions for liquid-metal fast breeder reactors.
(*g*) Improvement on usual waterhammer approach has been developed.
(*h*) **Pulse Propagation in Fluid-Filled Tubes,** J. S. Walker, J. W. Phillips, *TAM Rept. No. 404*, UIUC (1975).
Perturbation Solutions for Steady One-Dimensional Waterhammer Waves, J. S. Walker, *J. Fluids Engrg.* **97,** pp. 260-262, 1975.

057-09037-110-00

FERROHYDRODYNAMIC BOUNDARY LAYERS

(*c*) Professor J. D. Buckmaster, Talbot Laboratory.
(*d*) Theoretical.
(*e*) Study treats boundary layers on bodies moving through ferroliquids in the presence of magnetic fields. Ferroliquids promise to play a major role in fluidic control devices and in high-speed printers using jets of ferroliquid ink controlled by magnetic fields. A good understanding of boundary layers in ferroliquids will be needed to make design predictions for these devices.

057-09038-000-54

STEADY FLOW THROUGH ROTATING VARIABLE-AREA DUCTS

(*b*) National Science Foundation.
(*c*) Professor J. S. Walker, Talbot Laboratory.
(*d*) Theoretical.
(*e*) Study treats liquid flows in expansions and contractions rotating about axes perpendicular to their centerlines. The results will relate directly to flows inside the impellers of hydraulic turbines and centrifugal pumps and indirectly to the effects of bottom topology on ocean currents.
(*h*) **Steady Flow in Rapidly Rotating Variable-Area Rectangular Ducts,** *J. Fluid Mech.* **69,** pp. 209-227, 1975.

057-09039-030-54

LARGE AMPLITUDE MOTION OF SELF-PROPELLING FILAMENTS

(*b*) National Science Foundation, Ford Foundation.
(*c*) Professor T. J. Lardner, Talbot Laboratory.
(*e*) An analysis of the hydrodynamics of filaments moving with finite amplitude sinusoidal motions has been completed. Expressions for various important physical quantities, such as propulsive velocity, normal and tangential drag coefficients, and power dissipation were obtained. The results can be used for a simplified analysis for filaments of non-zero thickness undergoing large amplitude motions.
(*h*) **Large Amplitude Motion of Self-Propelling Slender Filaments at Low Reynolds Numbers,** T. J. Lardner, J. Shen, P. Tam, W. Shack, *J. Biomech.* **8,** pp. 229-236, 1975.

057-09040-030-80

APPLICABILITY OF HYDRODYNAMIC ANALYSES OF SPERMATOZOAN MOTION

(*b*) Ford Foundation, National Science Foundation.
(*c*) Professor T. J. Lardner, Talbot Laboratory.
(*e*) An investigation of the applicability of a simplified hydrodynamic analysis to the quantitative description of the motion of both sea urchin and mammalian sperm has been completed. A comparison of experimentally measured and theoretically predicted motions was made to check the validity of the analysis. The results for the sea urchin sperm showed good agreement, while the results for mammalian sperm showed poor agreement.
(*h*) **A Long Wave Length Approximation to Spermatozoan Swimming in a Channel,** T. J. Lardner, W. Shack, *Bull. Math. Biology* **36,** pp. 435-442, 1974.
The Swimming of Spermatozoa in An Active Channel, T. J. Lardner, R. Smelser, W. Shack, *Bull. Math. Biology* **7,** pp. 349-355, 1974.

057-09041-020-54

STATISTICAL THEORY OF TURBULENCE

(*b*) National Science Foundation.
(*c*) Professor Ronald J. Adrian, Talbot Laboratory.
(*d*) Theoretical.
(*e*) A model equation for the probability density of temperature and velocity has been used in the investigation of various turbulent flows with buoyancy, including homogeneous stratified shear flows with arbitrary Richardson number, inhomogeneous Rayleigh convection and inhomogeneous Richardson numbers. In the last case it is found that the empirical power laws for local free convection are similarity solutions of the p.d.f. equation.

057-09042-020-54

TURBULENT FREE AND FORCED CONVECTION

(*b*) National Science Foundation.
(*c*) Professor Ronald J. Adrian, Talbot Laboratory.
(*d*) Experimental and theoretical.
(*e*) Unsteady turbulent free convection over large horizontal surfaces is an important phenomenon in the planetary boundary layer that is being studied experimentally on the laboratory scale. Fluctuating velocities and temperatures are measured using a two component laser—Doppler velocimeter and very small temperature sensors which are scanned through the fluid to obtain the terms appearing in the balance equations for mean turbulent kinetic energy and heat flux and the application of conditional averaging techniques in order to better define quasi deterministic structures within the flow. Current higher order closure models are modified to include buoyancy effects for homogeneous and inhomogeneous boundary-layer type flows.
(*h*) **Turbulent Convection in Water Over Ice,** R. J. Adrian, *J. Fluid Mech.* **69,** pp. 753-781, 1975.

057-09043-700-54

EFFECTS OF SNR ON THE FREQUENCY DEMODULATIONS OF LDV SIGNALS

(*b*) National Science Foundation.
(*c*) Professor Ronald J. Adrian, Talbot Laboratory, Professor J. H. Whitelaw, Imperial College, Mr. J. C. Humphrey, Imperial College.
(*d*) Experimental and theoretical.
(*e*) The laser-Doppler velocimeter is becoming an increasingly more important tool in hydraulics research. In general, the measured frequency of a laser-Doppler velocimeter signal that contains noise is not equal to the frequency of the pure Doppler signal. The relationship between measured and true frequency is being investigated theoretically for the limiting cases of very small and very large scattering particle concentrations.
(*h*) **Frequency Measurement Errors Due to Noise in LDV Signals,** R. J. Adrian, J. A. C. Humphrey, J. H. Whitelaw, in *The Accuracy of Flow Measurements by Laser Doppler Techniques*, ed. Buchhave, Delhage, Durst, George, Refslund and Whitelaw. Copenhagen: Tech. Univ. Denmark, pp. 287-311, 1976.

057-09044-700-54

TWO-DIMENSIONAL BI-POLAR LASER DOPPLER VELOCIMETER

(*c*) Professor Ronald J. Adrian.
(*d*) Experimental.
(*e*) A laser-Doppler velocimeter is being developed for the measurement of local, instantaneous fluid velocities in the range of 0.01 cm sec^{-1}. The instrument utilizes an equilateral three-beam configuration in which two of the beams are frequency shifted by an acousto-optic modulator. This arrangement permits measurement of two orthogonal velocity components, and their signs in regions close to a flow boundary. In particular, measurements of the normal component in wall turbulence are possible.
(*h*) **Two Component Laser-Doppler Velocimeter,** R. J. Adrian, *J. Phys. E.* **8,** pp. 723-726, 1975.

057-09045-700-54

ELECTROMAGNETIC SCATTERING THEORY OF LASER-DOPPLER VELOCIMETERS

(*b*) National Science Foundation.
(*c*) Professor Ronald J. Adrian.
(*d*) Theoretical.
(*e*) In the measurement of both liquid and gas velocities, the performance of an LDV can be substantially up-graded by suitable choices of scattering particles and light receiving apertures. In this study the strength and quality of an LDV signal obtained from a single scattering particle depend strongly on the particle's scattering properties and on the size and shape of the light collecting aperture. Using the Mie scattering theory, an analysis of these effects is being performed which predicts the magnitude, phase and polarizing of the Doppler and pedestal components of an LDV signal in terms of the illuminating beam geometry, the particle properties, and the receiving aperture. Systems having either two or three illuminating beams with arbitrary polarization are considered.
(*h*) **Evaluation of LDV Performance Using Mie Scattering Theory,** R. J. Adrian, W. E. Earley, *Proc. Symp. Laser Anemometry*, Minneapolis, Minn., pp. 426-54, 1976.

057-10275-020-00

TURBULENCE MODELING VIA CONDITIONAL AVERAGES

(*c*) Professor R. J. Adrian.
(*d*) Theoretical and experimental.
(*e*) Conditional averages, as the expected values of the velocity at one point in a turbulent flow given the velocities at other points, are the highest order unknowns in certain theories of turbulence. Closure of the theories requires approximations for the conditional averages. The theories include the equation for the probability density of the velocity and optimal algorithms for integrating the turbulent Navier-Stokes equations. Optimal linear estimation is being studied experimentally and closures of the two-point probability-density function equation are being studied theoretically.

057-10276-030-00

FLOW PHENOMENA OF PRISMATIC BODIES

(*c*) J. M. Robertson with colleagues at Colorado State University.
(*d*) Experimental.
(*e*) Buildings in winds are subjected to steady and unsteady forces and pressures, the nature of which are intimately associated with the flow field. A significant feature of the flow past prismatic shapes is the separation-reattachment phenomenon. For the square prism the reattachment locale and steady/unsteady pressure field are studied in terms of orientation of the prism to the flow.
(*h*) **Pressure Field at Reattachment of Separated Flows,** J. M. Robertson, *Proc. 2nd U.S. Natl. Conf. on Wind Engrg. Res.* **IV-26-1-3,** 1975.
A Reynolds Number Effect on Flow Past Prismatic Bodies, J. M. Robertson, *Mechanics Research Comm.* **2,** pp. 279-282, 1975.

057-10277-700-00

PITOT RODS FOR LARGE PIPELINES

(*c*) J. M. Robertson.
(*d*) Experimental.
(*e*) Special Pitot-static heads at the ends of long rods are often used to determine the water flow rate in large pipelines. Velocity-indication uncertainties due to wall proximity, blockage, vibration and manometer-pulsation effects are being studied.

057-10278-210-54

NUMERICAL CALCULATION OF VISCOUS FLOWS IN THREE-DIMENSIONAL CONDUITS

(*b*) National Science Foundation.
(*c*) M. E. Clark.
(*d*) Computational.
(*e*) The moderate-Reynolds number flow of an incompressible fluid through a short radius 90-degree bend in a pipe is being calculated via finite-difference techniques in the primitive variables. The appearance of appreciable secondary flows is a significant occurrence. Modes of simply evidencing such secondary flows are being reviewed.
(*g*) Calculations of an asymmetric square hump in straight pipe at a Reynolds number of 25 has brought out the strong secondary currents developed, especially their change in sense as the hump is passed.

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INDIANA UNIVERSITY, Department of Geology, 1005 East Tenth Street, Bloomington, Ind. 47401. Dr. Haydn H. Murray, Department Chairman.

058-10562-820-00

CHLOROFLUOROMETHANES IN GROUNDWATER

(*c*) Professor John Hayes.

058-10563-860-00

HYDROLOGIC CIRCULATION, SEDIMENTATION, AND NUTRIENT INPUT AND UTILIZATION IN MONROE RESERVOIR NEAR BLOOMINGTON, INDIANA

(*c*) Professor Robert Ruhe.

058-10564-870-00

DETERMINATION OF ORGANIC POLLUTANTS IN URBAN HYDROLOGY

(*c*) Professors Warren Meinschein and Robert Ruhe.

058-10565-870-00

EFFECTS OF HEATED DISCHARGE UPON AQUATIC RESOURCES OF WHITE RIVER AT PETERSBURG, INDIANA

(*c*) Professor Robert Ruhe.

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INGERSOLL-RAND RESEARCH, INC., Fluid Mechanics and Thermal Sciences Section, P.O. Box 301, Princeton, N. J. 08540. Dr. W. A. McGahan, Director of Research.

059-09030-630-70

COVER GAS SEAL DEVELOPMENT PROGRAM

(*b*) Breeder Reactor Dept., General Electric Co.
(*c*) Dr. G. W. Pfannebecker, J. F. Gardner.
(*d*) Experimental and analytical; applied research and development.
(*e*) Technology development of a non-rubbing hydrostatic gas seal for the LMFBR Demonstration Plant main circulating pumps.
(*f*) Discontinued.
(*g*) Static mode testing demonstrated the design of the hydrostatic non-rubbing seal to perform the cover gas sealing function with adequate gas film stiffness at acceptable leakage flow rates.
(*h*) Design and test reports submitted to sponsoring agency.

059-10612-630-00

PUMP PERFORMANCE STUDY USING AIR TESTING

(*c*) Dr. G. W. Pfannebacker, D. P. Sloteman.
(*d*) Experimental, applied research and development.

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(*e*) Develop air testing techniques for hydraulic design of pumps. Wind tunnel testing of pump components conducted and correlated with existing pump test data.
(*g*) Currently awaiting hydraulic test data on redesigned pump components to assess validity of air testing techniques as design tool.
(*h*) Internal report.

059-10613-260-34

INJECTOR FOR CONTINUOUS INJECTION INTO A PIPELINE OF RUN OF THE MINE COAL FROM A CONTINUOUS MINER–JET PUMP MODEL STUDY.

(*b*) U.S. Bureau of Mines.
(*c*) K. D. Paul, A. Saad, R. Malsbury, J. L. Dussourd.
(*d*) Experimental and analytical; applied research and development.
(*e*) A study involving the design and development of a coal injector for coarse slurry transport.
(*g*) An investigation during the first phase of this project concluded that a jet pump injector receiving coarse dry coal was the most promising concept for underground coal mining applications. An experimental subscale model study established the design parameters as well as operational problems. This study concluded the over-all performance and operability of the injector is very attractive. A study is underway to determine the best way to integrate the injector in a complete haulage system.
(*h*) Phase I and Phase IIA Reports submitted to sponsor.

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INTERNATIONAL BUSINESS MACHINES CORPORATION, Thomas J. Watson Research Center, Post Office Box 218, Yorktown Heights, N. Y. 10598. R. E. Gomory, IBM Vice President and Director of Research.

060-07367-810-20

ENVIRONMENTAL SCIENCES–HYDROLOGY

(*c*) J. R. Wallis.
(*d*) Basic and applied research.
(*e*) Stochastic hydrology.
(*h*) **Statistics of Data Transfer,** N. C. Matalas, E. Todini, J. R. Wallis, *World Meteorological Organization Operational Hydrology Rept. No. 8, Hydrological Network Design and Information Transfer, Proc. Intl. Seminar*, Univ. of Newcastle upon Tyne (U.K.) and World Meteorological Organization and the Intl. Assoc. of Hydrological Sciences, Newcastle upon Tyne, pp. 103, 1974.
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CLS: Constrained Linear Systems, S. Martelli, E. Todini, J. R. Wallis, *Mathematical Models for Surface Water Hydrology*, Ed. T. A. Ciriani, A. Mianone, J. R. Wallace, John Wiley & Sons, Apr. 1977.
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SPUMA: Simulation Package Using Matalas Algorithm, G. Finzi, E. Todini, J. R. Wallis, *Mathematical Models for Surface Water Hydrology*, Ed. T. A. Ciriani, A. Mianone, J. R. Wallis, John Wiley & Sons, Apr. 1977.
MALSAK: Markov and Least Squares ARMA Kernels, G. Finzi, E. Todini, J. R. Wallis, *Mathematical Models for Surface Water Hydrology*, Ed. T. A. Ciriani, A. Miaone, J. R. Wallis, John Wiley & Sons, Apr. 1977.
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Regional Skew in Search of a Parent, N. C. Matalas, J. R. Slack, J. R. Wallis, *Water Resour. Res.* **6,** p. 815, Dec. 1975.
Effect of Sequence Length on the Choice of Assumed Distribution of Floods, J. R. Wallis, N. C. Matalas, J. R. Slack, *Water Resour. Res.* **3,** p. 457, June 1976.
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Apparent Regional Skew, J. R. Wallis, N. C. Matalas, J. R. Slack, *Water Resour. Res.* **1,** p. 159, Feb. 1977.

060-09992-300-00

ENVIRONMENTAL SCIENCES–GEOMORPHOLOGY

(*c*) J. S. Smart.
(*d*) Basic research.
(*e*) Fluvial geomorphology.
(*h*) **Channel Networks,** J. S. Smart, *Advances in Hydroscience VIII*, Academic Press, N.Y., 1972.
Quantitative Characterization of Channel Network Structure, J. S. Smart, *Water Resour. Res.* **8,** pp. 729-736, 1972.
Some New Methods of Topologic Classification of Channel Networks, C. Werner, J. S. Smart, *Geog. Analysis* **5,** pp. 271-295, 1973.
The Random Model in Fluvial Geomorphology, J. S. Smart, *Proc. Symp. on Fluvial Geomorphology*, pp. 25-49, Suny, Binghamton, 1973.
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Applications of the Random Model of Drainage Basin Composition, J. S. Smart, C. Werner, *Earth Surface Processes* **1,** pp. 219-233, John Wiley & Sons Ltd., 1976.
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060-09993-800-00

OPTIMIZATION OF THE OPERATION OF A WATER RESOURCE SYSTEM

(*c*) Kai-Ching Chu.
(*d*) Applied research, operation.
(*e*) Development of a computer program for the management of water resources: Modeling of a water resources system. The model concerns the water release and distribution problem of Karun River and its tributaries in Khuzestan, Iran. The system consists of three dams with three hydroelectric plants, 16 irrigation areas and 13 municipal/industrial demand locations. Water inflows fluctuate. A large nonlinear stochastic programming model was formulated to determine the optimal monthly water releasing rules from the dams for the whole year. Detailed water distributions to various sectors are treated as subproblems of linear programmings.
(*g*) The project has resulted in an advance, general methodology for treating the optimal operation of such water resource systems. Uncertainties in water inflows and water demands have been considered in determining the optimum water releasing rules.
(*h*) **Optimization of a Water Resources System by Stochastic Programming with Resource and Linear Rules,** R. J. Peters, K. C. Chu, M. Jamshidi, *9th Intl. Symp. on Math. Programming*, Budapest, Hungary, Aug. 1976.
Modeling the Operation of Khuzestan Water Resources System by Stochastic Programming, R. J. Peters, K. C. Chu, M. Jamshidi, *Intl. Conf. on Computer Applications in Developing Countries*, Bankok, Thailand, Aug. 1977.

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IOWA INSTITUTE OF HYDRAULIC RESEARCH, The University of Iowa, Iowa City, Iowa 52242. Dr. John F. Kennedy, Director.

061-00066-810-05

HYDROLOGIC STUDIES, RALSTON CREEK WATERSHED

(*b*) Agricultural Research Service and U.S. Geological Survey.
(*c*) Professors J. W. Howe and T. E. Croley II.
(*d*) Field investigation, applied research, and M.S. theses.
(*e*) Study continuously in progress since 1924 on the three square-mile north branch of Ralston Creek. An area of similar size on the south branch of Ralston Creek came under observation in 1967. The study involves discharge measurement by the U.S.G.S. and rainfall measurement at three automatic recording stations. Rainfall data are collected by the Agricultural Research Service and published by the Weather Bureau. A record of the urbanization of the area through aerial photos and numerous pictures taken at the same point year after year is being accumulated. Records on rainfall, runoff, groundwater levels, sediment transportation, and land use are combined in an annual report.
(*g*) Yearly records available for examination at Iowa Inst. of Hydraulic Research.
(*h*) Reports prepared annually since 1924 available in files at the Iowa Inst. of Hydraulic Research. Summary of 33-year record published as *Bull. 16 of the Iowa Highway Research Board* in 1961; available on loan from Iowa Highway Commission, Ames, Iowa.

061-00067-810-30

COOPERATIVE SURFACE-WATER INVESTIGATIONS IN IOWA

(*b*) U.S. Geological Survey, Agric. Research Service, Natl. Weather Service, IIHR, Graduate College.
(*c*) District Chief, Water Resources Div., U.S. Geol. Surv., Iowa City, Iowa.
(*d*) Field investigation; collection of basic streamflow data.
(*e*) Streamflow and sediment measuring stations maintained throughout the State of Iowa cooperatively on a continuous basis. Records collected by standard methods of U.S.G.S.
(*g*) Records of streamflow and sediment discharge computed yearly.
(*h*) Records contained in open-file reports published annually, and in Water-Supply Papers published at five year intervals; available from U.S. Geological Survey.

061-02091-520-20

RESEARCH ON SHIP THEORY

(*b*) Office of Naval Research and Naval Ship Research and Development Center.
(*c*) Dr. L. Landweber.
(*d*) Experimental and theoretical; basic research.
(*e*) Determine the laws governing the forces, moments, and motions of ships. Work is under way on development of procedure for computing potential flow about ship forms; higher-order gravity wave theory for ship forms; effect of tank size on ship-model resistance, resolution of viscous and wave drag by means of wake and surface-profile measurements; conformal mapping of ship sections; thick boundary layers about bodies of revolution.
(*h*) **On a Solution of the Lavrentiev Wake Model and Its Cascade,** A. C. Lin, L. Landweber, *J. Fluid Mechanics* **79,** 4, Mar. 1977.
Flow Interaction Near the Tail of a Body of Revolution, Part 1: Flow Exterior to Boundary Layer and Wake, A. Nakayama, V. C. Patel, L. Landweber, *ASME J. Fluids Engrg.* **98,** 3, pp. 531-537, Sept. 1976.
Flow Interaction Near the Tail of a Body of Revolution, Part 2: Iterative Solution for Flow Within and Exterior to Boundary Layer and Wake, A. Nakayama, V. C. Patel, L. Landweber, *ASME J. Fluids Engrg.* **98,** 3, pp. 538-549, Sept. 1976.
Accurate Parametric Representation of Ship Sections by Conformal Mapping, L. Landweber, M. Macagno, *Proc. 1st Intl. Conf. Numerical Ship Hydrodynamics*, Oct. 1975.
Further Development of a Procedure for Determination of Wave Resistance from Longitudinal-Cut Surface-Profile Measurements, C. E. Tsai, L. Landweber, *J. Ship Research* **19,** 2, June 1975.
Effect of Tank Walls on Ship-Model Resistance, L. Landweber, A. Nakayama, *Proc. 14th Intl. Towing Tank Conf.* **3,** Ottawa, Aug. 1975.
Technique for Determining the Viscous Drag of a Ship Model, L. Landweber, *Proc. 14th Intl. Towing Tank Conf.*, Aug. 1975.
Prediction of the Viscous Resistance of Ships Using Equivalent Bodies of Revolution, A. Nakayama, V. C. Patel, L. Landweber, *Proc. 17th American Towing Tank Conf.*, Calif. Inst. Tech., Pasadena, June 1974.
Effect of Wake on Wave Resistance of a Ship Model, L. Landweber, M. Moreno, L. Perez-Rojas, *Iowa Inst. Hydr. Res. Tech. Rept. No. 180*, Aug. 1975.

061-07368-410-11

SEDIMENT ENTRAINMENT AND SUSPENSION BY SHOALING WAVES

(*b*) Coastal Engrg. Res. Center, U.S. Army Corps of Engineers.
(*c*) J. R. Glover and J. F. Kennedy.
(*d*) Experimental and theoretical; basic research; Ph.D. thesis.
(*e*) Experiments were conducted in oscillatory flow, "U-Tube" water tunnel, with the goal of determining the spatial and temporal distributions of suspended sediment concentration and velocity in oscillatory flows over rippled beds. Both a rippled, sediment bed and a rigid bed with a limited supply of sediment on it were utilized. Suspended sediment concentrations were measured by means of the Iowa electro-optical system, while crossed, coated hot wires were used to measure velocities. The outputs of the concentration and velocity transducers were sampled by means of an on-line computer using a signal-averaging procedure. The distributions of the mean, periodic, and random components of the concentration and velocity distributions were determined, as were the cross-correlations significant to the sediment continuity relation.
(*f*) Completed.
(*g*) The experiments indicate that the mean sediment concentration diminishes very rapidly with elevation above the bed. Within each wave period there are four concentration peaks; each of these traces its origin to the sediment entrained from a ripple crest and swept past the probe. The peak magnitude of the periodic component of the concentration is comparable in magnitude and nearly linearly proportional to that of the mean concentration at a point. Considerable difficulty was encountered in measuring the velocities, due to the interaction between the sediment particles and the hot wire probes. The experimental data on the cross correlations interpreted in the light of the one-dimensional sediment continuity relation (the Schmidt equation) indicated that the longitudinal transport of sediment is very important, i.e., a simple balance does not exist between the settling velocity and the upward sediment diffusion velocity. The ripples were found to play a very dominant role in the sediment entrainment and suspension process. The large, captive eddy generated in the lee of each ripple during each half-period and the intense shear stress on the stoss side of each ripple throw the sediment into suspension and are largely responsible for maintenance of the suspended sediment field. The presence of sediment significantly alters the flow characteristics, amplifying both the mean and fluctuating components of the turbulent components of the velocity.
(*h*) **Sediment Entrainment by Oscillatory Flow,** T. Nakato, F. A. Locher, J. R. Glover, J. F. Kennedy, *Proc. of 16th Congress of IAHR*, Sao Paulo, Brazil, Aug. 1975.
Characteristics of Iowa Sediment Concentration Measuring System, T. Nakato, F. A. Locher, J. R. Glover, J. F. Ken-

nedy, *Proc. 15th Intl. Conf. Coastal Engrg.*, Honolulu, Hawaii, July 1976.
Wave Entrainment of Sediment from Rippled Beds, T. Nakato, F. A. Locher, J. R. Glover, J. F. Kennedy, *Proc. ASCE, J. Waterway, Port, Coastal, and Ocean Div.* **103,** WW1, Feb. 1977.

061-07376-270-40

FLUID MECHANICS OF THE SMALL INTESTINE

(*b*) National Institutes of Health.
(*c*) Dr. E. O. Macagno.
(*d*) Experimental and analytical; basic research, graduate theses.
(*e*) Determination of flow properties of chyme with U-tube, single-pulse, computer controlled, new apparatus. Analysis of flow induced by ring contractions with a longitudinal component; experiments on flow induced by conduit wall motions of circular and longitudinal types; experimental and theoretical study of mass transfer through walls.
(*g*) An analytical study has been completed of creeping flow due to ring contractions. An analytical model has been developed for flow induced by local unbiased oscillations of the conduit wall.
(*h*) **Longitudinal Contractions in the Duodenum: Their Fluid-Mechanical Function,** J. Melville, E. O. Macagno, J. Christensen, *Amer. J. Physiology* **228,** 6, 1975.
Phase Lock of Electrical Slow Waves and Spikes in Cat Duodenum, A. Sancholuz, T. Croley, J. Christensen, E. O. Macagno, J. Glover, *Amer. J. Physiology* **229,** 3, 1975.
Distribution of Spike Bursts in Cat Duodenum, A. Sancholuz, T. Croley, E. O. Macagno, J. Glover, J. Christensen, *Amer. J. Physiology* **229,** 4, 1975.
An Analytical Model of Flow Induced by Longitudinal Contractions in the Small Intestine, N. Denli, *M.S. Thesis*, Univ. of Iowa, Dec. 1975.

061-08036-060-33

MIXING AND TRANSFER OF HEAT IN OPEN CHANNEL FLOW

(*b*) Office of Water Resources Research, Dept. of the Interior.
(*c*) Dr. W. W. Sayre.
(*d*) Experimental (laboratory) and theoretical; applied research, contributing toward M.S. and Ph.D. theses.
(*e*) Investigation of the processes by which effluent heated water mixes with flowing streamwater, and the excess heat is transferred to the surrounding environment, and how these processes combine to produce a particular temperature distribution pattern in the stream. Influence of density gradient on vertical distribution of longitudinal velocity.
(*f*) Completed.
(*g*) Depth-averaged vertical mixing coefficients, ϵ_y/u_1d, found to vary from about 0.005 for initial densimetric Froude number, IF_{Do}, of 1 to an asymptotic value of 0.063 for $IF_{Do} \geq 10$. In addition to suppressing vertical turbulent mixing, vertical density gradient suppresses corner-generated secondary circulation. Buoyancy-induced secondary circulation significantly increases initial rate of transverse spreading. For u_1 $(\Delta\rho gd/\rho)^{1/2}$ buoyancy effects are especially strong, and bimodal transverse temperature distributions occur. Buoyancy effects can either increase or decrease the rate of longitudinal spreading by an amount which is not large. In a density-stratified flow, the velocity is increased slightly near the water surface and retarded slightly in the lower part of the flow. The effect is insignificant for $IF_{Do} > 1.5$.
(*h*) **Vertical Temperature Profiles in Open-Channel Flow,** E. J. Schiller, W. W. Sayre, *J. Hydraulics Div., ASCE* **101,** HY6, *Proc. Paper 11389*, pp. 749-761, June 1975.
Buoyancy Effects in Thermally-Stratified Open-Channel Flow, G. J. Hwang, *Ph.D. Thesis*, Univ. of Iowa, July 1975.
Longitudinal Mixing of Heated Water in Open-Channel Flow, J. Grimm-Strele, *Ph.D. Thesis*, Univ. of Iowa, Dec. 1975.

061-08828-340-73

MOVABLE-BED HYDRAULIC MODEL STUDY FOR COOPER NUCLEAR STATION INTAKE SYSTEM

(*b*) Nebraska Public Power District.
(*c*) Dr. William W. Sayre.
(*d*) Experimental (laboratory); applied research, design.
(*e*) Model study to reduce amount of sediment taken into circulating- and service-water systems, and amount of sediment deposited in the intake structure.
(*f*) Completed.
(*g*) Seven different schemes, designed to reduce the amount of sediment entering the intake structure and circulating- and service-water systems by modifying the approaching flow, were investigated in this study. The best results were obtained with a combination training wall-skimming weir placed parallel to the face of the intake structure. A number of variations of this scheme were tested before arriving at an optimum configuration which satisfied the channel-encroachment constraint of the Corps of Engineers. The model results indicate that the configuration finally adopted should effect a 40 to 70 percent reduction in the amount of suspended sediment entering the circulating- and service-water systems, for the river flow conditions which prevail most of the time. A very large reduction in the amount of gravel entering the intake structure is also expected.
(*h*) **Undistorted Movable-Bed Model Study for a River and Power Plant Intake System,** Y. Onishi, M. J. Hroncich, W. W. Sayre, *Proc. Symp. Modeling Techniques, ASCE*, San Francisco, pp. 521-539, Sept. 1975.

061-08830-870-73

FIELD TESTING OF DIFFUSER PIPE SYSTEM FOR DISCHARGING CONDENSER COOLING WATER AT QUAD CITIES NUCLEAR POWER STATION

(*b*) Commonwealth Edison.
(*c*) Dr. W. W. Sayre.
(*d*) Field investigation; applied research, operation; contributing toward Ph.D. thesis.
(*e*) Periodic temperature and velocity distribution measurements in the Mississippi River upstream and downstream from the diffuser pipe discharge system to ensure that the plant discharge is meeting the thermal standards of the Illinois Pollution Control Board and other concerned environmental protection authorities. Comparison of prototype performance with laboratory model predictions.
(*f*) Completed.
(*g*) The diffuser-pipe system was found to be in compliance with the applicable thermal standards by a comfortable margin during all of the river surveys. The results of the study indicate that satisfactory performance in the full open-cycle mode should be achievable for river discharges as low as about 18,000 cfs. The gross behavior of the jets in the initial mixing region was found to be in rough accordance with the behavior of a momentum jet discharging into a quiescent, infinite body of water. The momentum-jet type behavior began to break down when the confining effects of the free-surface and bottom boundaries came into play. Buoyance effects only became evident farther downstream in cases where the momentum was largely diffused before complete mixing was achieved. For the most part, good agreement was obtained between prototype and model data.
(*h*) **Prototype and Model Studies of the Diffuser-Pipe System for Discharging Condenser Cooling Water at the Quad Cities Nuclear Power Station,** A. D. Parr, *Ph.D. Thesis*, Univ. of Iowa, May 1976.

061-08831-870-75

INVESTIGATION OF SURFACE-JET THERMAL OUTFALL FOR IATAN STEAM ELECTRIC GENERATING STATION

(*b*) Black and Veatch Consulting Engineers.
(*c*) Dr. William W. Sayre.
(*d*) Computational; design, operational.

(*e*) Preliminary feasibility investigation of a surface-jet thermal outfall system for discharging the condenser cooling water from the proposed Iatan Steam Electric Generating Station into the Missouri River.

(*f*) Completed.

(*g*) Hydrographic measurements by the U.S. Geological Survey show that the geometry of and distribution of flow in the river channel is favorable for a surface-jet scheme. Downstream temperature-rise distributions are predicted for surface jets discharging both at right angles and parallel to the ambient flow for selected river discharges. The prediction technique takes into account the properties of the ambient flow, including the mixing mechanisms, as well as those of the jet. The right-angle discharge is predicted to be superior in almost every respect. For one-unit operation at full plant load and a river discharge of 10,000 cfs, it is predicted that the 5°F temperature-rise isotherm would cover a horizontal area of less than 0.5 acres and the zone-of-passage wherein the temperature rise is less than 5°F exceeds 85 percent of the river flow.

(*h*) **Investigation of Surface-Jet Thermal Outfall for Iatan Steam Electric Generating Station,** W. W. Sayre, *Iowa Inst. of Hydr. Res. Rept. No. 167*, Apr. 1975.
Transverse Flow Distribution in Natural Streams as Influenced by Cross-Sectional Shape, O. Sium, *M.S. Thesis*, Univ. of Iowa, July 1975.

061-08832-870-73

THERMAL OUTFALL SYSTEM FOR DRESDEN NUCLEAR STATION

(*b*) Commonwealth Edison.

(*c*) Dr. W. W. Sayre.

(*d*) Laboratory model study, computational; applied research, design, operation; contributing to M.S. thesis.

(*e*) Laboratory model study to guide design of slot-jet thermal outfall system for discharging circulating water from Unit 1 and blowdown discharge from Units 2 and 3 of Dresden Nuclear Station. Development of monitoring criteria based on laboratory and field measurements. Frequency analysis of river discharge and temperature data to determine limitations on plant operating conditions necessary to achieve compliance with thermal standards of Illinois Pollution Control Board for various background environmental conditions.

(*f*) Completed.

(*g*) The results of hydraulic model studies and field temperature surveys are used to relate the mixing performance of the outfall structure to plant discharge conditions and the Illinois River discharge. A probabilistic model for computing the probability of violation for a given set of plant discharge conditions is then derived. In this model the discharge and temperature of the Illinois River and the temperature difference between the Illinois and Kankakee Rivers are represented as random variables. Finally, probabilities of violation are computed for different periods of the year and different plant operating conditions. In general, larger probabilities of violation were found for the summer months when combinations of low Q_{ILL} and high T_{ILL} are more apt to occur. Compliance-test procedures and criteria for computing reductions in plant load necessary to achieve compliance when violation is indicated are presented.

(*h*) **Investigation and Evaluation of the Thermal Discharge Systems of Dresden Nuclear Station,** J. C. Hwang, *M.S. Thesis*, Univ. of Iowa, May 1976.

061-08833-870-70

AQUATIC ECOLOGY AND MIXING CHARACTERISTICS OF BEAVER SLOUGH, MISSISSIPPI RIVER, NEAR CLINTON, IOWA

(*b*) E. I. DuPont deNemours and Co.

(*c*) W. W. Sayre.

(*d*) Field investigation; applied research.

(*e*) Field investigation to collect hydrographic and chemical data for evaluating environmental impact of present and improved systems for treating chemical wastes discharged into Beaver Slough from the DuPont Film Processing Plant at Clinton. Data includes detailed measurements of sulfate concentrations, pH, temperature, transverse velocity distribution, and bottom benthic samples in the region of the slough occupied by the plume, and background measurements upstream from the plant.

(*f*) Completed.

(*g*) Mixing rates in the slough were found to be highly sensitive to a number of density-related phenomena and cannot be depended upon for any significant contribution to near-field dilution. From a theoretical and laboratory study of the natural buffering mechanisms and chemical equilibrium relationships for the slough, it was determined that a physical dilution of at least 60 to 1 is needed to meet the applicable mixing-zone standards at the critical low flow conditions. In addition to the physical dilution, sufficient vertical mixing and surface renewal to release excess carbon dioxide to the atmosphere–a prerequisite to the attainment of an equilibrium pH level–is needed. To achieve the required dilution and release of CO_2 to the atmosphere within the allowed mixing zone, an outfall structure consisting of a mulitple-port, submerged jet diffuser system was proposed.

(*h*) **Assessment of the Chemical Impact of Clinton Film Plant Wastewater on Beaver Slough Water Quality,** K. D. Tracy, W. W. Sayre, D. B. McDonald, *Iowa Inst. Hydr. Res. Limited Dist. Rept. No. 28*, Mar. 1975.
Investigation of Wastewater Outfall for Clinton Film Plant: Assessment of Chemical Impact and Analysis of Physical Mixing Characteristics of Beaver Slough, W. W. Sayre, K. D. Tracy, D. B. McDonald, *Iowa Inst. Hydr. Res. Tech. Rept. No. 183*, Dec. 1975.

061-08834-010-21

FURTHER STUDIES OF THE THICK AXISYMMETRIC TURBULENT BOUNDARY LAYER

(*b*) Naval Ship Research and Development Center.

(*c*) Dr. V. C. Patel.

(*d*) Experimental and theoretical; basic research; Ph.D. thesis.

(*e*) To make detailed measurements in the thick boundary layer and the near wake of a body of revolution and use the data to verify and improve methods for the prediction of the flow in the tail region of such bodies.

(*g*) Mean flow and turbulence measurements have been made in the boundary layer and the wake of a low-drag body of revolution. Some aspects of the data are reported in the publications listed below. The data are being analyzed and used to guide the development of a differential method for the continuation of the boundary layer calculation into the wake.

(*h*) **Flow Interaction Near the Tail of a Body of Revolution, Part I: Flow Exterior to Boundary Layer and Wake,** A. Nakayama, V. C. Patel, L. Landweber, *ASME J. Fluids Engrg.* **98,** 3, pp. 531-537, Sept. 1976.
Flow Interaction Near the Tail of a Body of Revolution, Part II: Iterative Solution for Flow Within and Exterior to Boundary Layer and Wake, A. Nakayama, V. C. Patel, L. Landweber, *ASME J. Fluids Engrg.* **98,** 3, pp. 538-549, Sept. 1976.
Importance of the Near Wake in Drag Prediction of Bodies of Revolution, V. C. Patel, O. Guven, *AIAA J.* **14,** pp. 1132-1133, 1976.
Measurements in the Thick Axisymmetric Turbulent Boundary Layer and the Near Wake of a Low-Drag Body of Revolution, V. C. Patel, Y. T. Lee, O. Guven, *Proc. Penn-State Univ. Symp. Turbulent Shear Flows*, pp. 9.29-36, 1977.

061-10359-870-60

MIXING OF POWER-PLANT HEATED EFFLUENTS WITH THE MISSOURI RIVER

(*b*) Iowa Energy Policy Council.

(*c*) Dr. William W. Sayre.

(*d*) Analytical; applied research; M.S. thesis.

(*e*) Thermal plume data obtained in the Missouri River downstream from the Fort Calhoun and Cooper Nuclear Stations, together with detailed information about the channel geometry needed to synthesize the transverse flow distribution are used to adapt and refine a mathematical model for steady-state transverse mixing in natural streams for the purpose of predicting thermal plumes in fast-flowing turbulent rivers.
(*f*) Completed.
(*g*) The model is found to provide a good basis for predicting thermal plumes in the Missouri River and similar streams. In addition to the transverse distribution of flow, applying the model requires the determination of two parameters, one relating to the initial near-field dilution resulting from the interaction of the thermal discharge with the ambient flow, and the other governing the far-field transverse mixing due to mechanisms associated with the ambient flow. The variation of the empirically determined initial-dilution and transverse diffusion parameters with different plant discharge, channel geometry, and ambient flow characteristics is examined with mixed results.
(*h*) **Mixing of Power-Plant Heated Effluents with the Missouri River,** R. Caro-Cordero, *M.S. Thesis*, Univ. of Iowa, May 1977.
Mixing of Power-Plant Heated Effluents with the Missouri River, R. Caro-Cordero, *Iowa Inst. Hydr. Res. Tech. Rept. No. 203*, June 1977.

061-10360-220-30

TRANSPORT OF SEDIMENT AND BED FORMS IN ICE-COVERED ALLUVIAL STREAMS

(*b*) U.S. Geological Survey and Iowa Institute of Hydraulic Research.
(*c*) Dr. William W. Sayre.
(*d*) Experimental and analytical; applied research; M.S. thesis.
(*e*) A series of experiments with equivalent (same slope and discharge) free- and covered-surface flows was conducted in a sand-bed laboratory flume for the purpose of determining the effect of an ice cover on sediment transport and bed forms. In the covered-surface experiments, an ice cover was simulated by a system of hinged plywood panels. In both the covered- and free-surface flows, detailed data were obtained on bed forms, velocity, suspended sediment distribution, and total sediment load.
(*g*) Experiments completed, analysis in progress.

061-10361-750-00

EFFECTS OF VERTICAL DISTORTION ON THE HYDRAULIC MODELING OF SURFACE JETS IN RIVERS

(*b*) Iowa Institute of Hydraulic Research.
(*c*) Dr. William W. Sayre.
(*d*) Experimental; applied research; Ph.D. thesis.
(*e*) A series of 36 experiments conducted in triplets, wherein experiments were repeated with two- and four-fold increases in depth but with constant jet densimetric Froude number, jet aspect ratio, and jet-to-ambient velocity and discharge ratios, was performed in a 12-foot wide rectangular flume. The purpose of the investigation is to evaluate the effect of vertical distortion on the following thermal plume properties: centerline temperature decay, jet trajectory, lateral spread, vertical thickness, areas enclosed by surface isotherms, and the cross-sectional area enclosed by the 5 °F excess temperature isotherm.
(*g*) Experiments completed, analysis still in progress.

061-10362-300-15

MECHANICS AND HYDRAULICS OF RIVER ICE JAMS

(*b*) Cold Regions Research and Engineering Laboratory, U.S. Army Corps of Engineers, Hanover, New Hampshire, and National Science Foundation.
(*c*) J. C. Tatinclaux.
(*d*) Experimental and analytical; basic research; Master's theses.
(*e*) An experimental and analytical study of the initiation and development of ice jams in narrow rivers and of compression strength of fragmented ice covers.
(*f*) Completed.
(*g*) The conditions of initiation of an ice jam by a simple surface obstruction in a channel, the equilibrium thickness of a jam in a narrow channel, and the compression strength of floating, fragmented ice covers were studied. The minimum concentration of ice floes in the opening of a simple obstruction at which a jam is initiated was found to be nearly independent of the ratio of width of constricted passage to channel width, and to be proportional to a negative power of the ratio of floe width to width of constricted passage. From energy analysis of floe submergence, a relationship between the equilibrium thickness of a narrow river jam and the approach floe characteristics was derived and verified experimentally. It was also found that the conditions of initiation of a jam and its equilibrium thickness were strongly influenced by the wetting or nonwetting properties of the material used for model ice floes. The compressive strength of floating, fragmented ice covers was found to be inversely proportional to loading rate, proportional to cover thickness, and independent of cover length.
(*h*) **Ice Jam Initiation by Partial Surface Obstructions,** C. L. Lee, *M.S. Thesis*, The Univ. of Iowa, May 1976.
Thickness of Ice Jams Due to Accumulation and Submergence of Ice Floes, T. P. Wang, *M.S. Thesis*, The Univ. of Iowa, May 1976.
A Laboratory Investigation of the Mechanics and Hydraulics of River Ice Jams, J. C. Tatinclaux, C. L. Lee, T. P. Wang, T. Nakato, J. F. Kennedy, *Iowa Inst. Hydr. Res. Tech. Rept. No. 186*, Mar. 1976.
Ice-Jam Mechanics, J. F. Kennedy, *3rd Intl. Symp. Ice Problems*, Hanover, N.H., 1975.

061-10363-190-15

FLEXURAL STRENGTH OF FRESHWATER AND SALINE ICE

(*b*) Cold Regions Research and Engineering Laboratory, U.S. Army Corps of Engineers, Hanover, New Hampshire.
(*c*) J. C. Tatinclaux.
(*d*) Experimental; basic research; Master's thesis.
(*e*) Small ice beams of variable salt concentration were tested under pure bending and concentrated load to determine the bending strength and modulus of elasticity of freshwater and saline ice.
(*f*) Completed.
(*g*) Small freshwater ice beams with homogeneous temperature distribution were tested under pure bending and concentrated load applied either on the top or on the bottom surface of the specimens. The direction of loading showed significant influence on the measured strength and elastic modulus of the specimens. This difference was tentatively attributed to the variation in ice crystal size between the top and bottom surfaces of an ice sheet. Fresh water and saline ice specimens were also tested semi-submerged in a water bath, with the top surface exposed to air of variable temperature. Loading rate had no effect on the flexural strength; the elastic modulus increased only slightly with increasing loading rate. In the range of air temperature investigated (0 °C to -15 °C), no significant variation of bending strength and elastic modulus was observed. On the other hand, bending strength and elastic modulus were found to be very rapidly decreasing functions of the square root of the brine volume.
(*h*) **An Experimental Investigation of Flexural Strength of Ice,** C. Y. Wu, *M.S. Thesis*, Univ. of Iowa, July 1976.
Laboratory Study of Flexural Strength and Elastic Modulus of Freshwater and Saline Ice, J. C. Tatinclaux, C. Y. Wu, *Iowa Inst. Hydr. Res. Tech. Rept. No. 190*, June 1976.

061-10364-220-13

FIELD STUDY OF SEDIMENT TRANSPORT CHARACTERISTICS AT THE MISSISSIPPI RIVER NEAR FOX ISLAND (RM 355-6) AND BUZZARD ISLAND (RM 349-50)

(*b*) U.S. Army Corps of Engineers, Rock Island District, Rock Island, Illinois.
(*c*) T. Nakato and J. F. Kennedy.

(*d*) Field investigation; basic research.

(*e*) The field study was conducted to elucidate the mechanisms and processes responsible for the recurrent shoaling which has been experienced in the reaches of the Mississippi River in the vicinities of Fox Island (between RM 355 and 356) and Buzzard Island (between RM 349 and RM 350), in Pool 20 between Keokuk, Iowa, and Canton, Missouri. Detailed data on transverse and streamwise distributions of flow velocity, suspended sediment discharge, bed-load discharge, bed-material properties, and flow depth were directly obtained in the field to describe the local unit sediment discharge of the stream and its dependence on the local flow properties and bed characteristics. From this information recommendations were developed for corrective measures which could be implemented to reduce the frequency and volume of dredging required to maintain the 9-foot navigation channel. Evaluation of the reliability of several existing sediment-discharge formulas also were made.

(*f*) Completed.

(*g*) The sediment responsible for the recurrent shoaling in the study reaches of the Mississippi River was found to originate from the Des Moines River. The relatively large quantity of sand transported by the Des Moines River as both bed load and suspended load tends to be deposited downstream from the confluence of the two rivers; the reduced sand transport capacity of the Mississippi River is in large measure a consequence of its relatively small energy slope. The field data showed that the bed-load discharge varies approximately as the fourth power of the mean velocity or the water discharge, while the suspended-load discharge was found to vary as the square of the water discharge. In the Buzzard Island reach the Mississippi River flow was found to bifurcate, with more than 25 percent of the water discharge passing through the secondary side channel, resulting in a considerable reduction of the mean velocity in the main channel. Closure of this side channel would roughly double the river sediment-transport capacity according to the empirical sediment-discharge formulas. None of the sediment discharge predictors tested (Engelund-Hansen, Inglis-Lacey, Einstein-Brown, Colby, and Toffaleti) was found to yield reliable results.

(*h*) **Field Study of Sediment Transport Characteristics of the Mississippi River Near Fox Island (RM 355-6) and Buzzard Island (RM 349-50),** T. Nakato, J. F. Kennedy, *Iowa Inst. Hydr. Res. Tech. Rept. No. 201*, May 1977.

061-10365-350-75

MODEL STUDY OF THE LAKE CHICOT PUMPING PLANT

(*b*) Stanley Consultants, Inc., Muscatine, Iowa.

(*c*) T. Nakato and J. F. Kennedy.

(*d*) Experimental investigation; basic research; M.S. thesis.

(*e*) A 1:24-scale laboratory model was constructed of the approach channel, forebay, pump sumps, pump bells, and gravity flow section of the Lake Chicot Pumping Plant which is to be constructed upstream from Lake Chicot in Chicot County, Arkansas, to pump flood waters into the Mississippi River. The pumps in the proposed plant will divert up to 6,500 cfs directly into the Mississippi River during high river stages, and up to 12,500 cfs will pass through the gravity-flow sections at low river stages. The plant will have twelve pumps consisting of ten identical pumps rated at 600 cfs each and two identical units rated at 250 cfs each. Each pumping bay will be 23-ft wide, and three gravity-flow bays, each 26-ft wide, will be located at the center of the plant structure. The principal purpose of the model investigation was to ascertain if the flows in the forebay and pump bays, and the flows to and through the gravity-flow sections of the structure display any objectionable features. The specific concern surrounding the forebay and pump bays was whether they provide approach flows to the pumps which are sufficiently uniform to allow satisfactory performance of the pumps.

(*g*) It was found that during pump operation, the forebay flows approaching the closed gravity bays located in the center of the pumping station were diverted laterally and entered the pump bays with a strong transverse component of velocity, leading to the production of separation, large captive eddies, and strong lateral nonuniformities in the pump-approach flows in the pump sumps. Modified trash-racks, with 12-in deep vertical bars on 6-in centers were found to serve as effective turning vanes and under most operating combinations, to produce pump-approach flows that are acceptably uniform. The possibility of scale effects affecting the performance of the modified model trash-racks was investigated in two idealized model sump bays with scales of 1:10 and 1:24, and it was found that no undesirable scale effects were present in the 1:24-scale model trash-racks. However, during the test with the 1:10-scale model, strong concentrated vortices were observed to occur within the model pump bell and to extend downward to the sump floor. Therefore, a four-vane vortometer was installed in the straight portion of the pipe line just above the suction bell to measure net flow circulation in the intake flow. Five pressure transducers also were installed on the sump floor immediately beneath the pump bell to record pressure fluctuations due to the concentrated floor vortices. With the aid of these instruments the best sump configuration in reducing vortex activity around the pump bell was sought.

(*h*) **Model Study of the Lake Chicot Pumping Plant,** T. Nakato, J. F. Kennedy, *Iowa Inst. Hydr. Res. Tech. Rept. No. 188*, Aug. 1976.

061-10366-300-61

ICE SUPPRESSION BY THERMAL DISCHARGES

(*b*) ISWRRI, OWRR and NSF.

(*c*) J. F. Kennedy and E. O. Macagno.

(*d*) Theoretical; experimental; field investigation.

(*e*) A computer-based numerical model has been developed to predict the winter-time temperature distributions and lengths of ice-free reaches in rivers subjected to artificial thermal inputs. Simplified relations have been developed to calculate the surface heat transfer from water to the atmosphere. Also, a closed-form relation has been derived to predict the water temperatures under stable meteorological conditions. The usefulness of the numerical solution is compared and verified with laboratory test results and field investigation data. The melting rate of ice covers due to warm water flow has also been investigated experimentally and theoretically and mathematical relations developed to calculate the melting rate under known flow and temperature conditions of water and overlying air.

(*f*) Completed.

(*h*) **Winter Regime Surface Heat Loss from Heated Streams,** P. P. Paily, E. O. Macagno, J. F. Kennedy, *Iowa Inst. Hydr. Res. Tech. Rept. No. 155*, Mar. 1974.

Winter-Regime Thermal Response of Heated Streams, P. P. Paily, E. O. Macagno, J. F. Kennedy, *Proc. ASCE, Hydr. Div.* **100,** Apr. 1974.

Thermal Response of Heated Streams, Solution by the Implicit Method, P. P. Paily, E. O. Macagno, *Iowa Inst. Hydr. Res. Tech. Rept. No. 165*, May 1974.

Winter-Regime Thermal Response of Heated Streams, P. P. Paily, *Ph.D. Thesis*, Univ. of Iowa, May 1974.

Influence of Air and Water Conditions on the Melting Rate of Ice Covers, M. A. Roman, *M.S. Thesis*, Univ. of Iowa, July 1974.

Numerical Prediction of the Thermal-Regime of Rivers, P. P. Paily, E. O. Macagno, *Proc. ASCE, Hydr. Div.*, Mar. 1976.

Hydrologic Response of Ice-Covered Streams, P. P. Paily, E. O. Macagno, J. F. Kennedy, *ISWRRI Report*, Ames, June 1973.

Rate of Recession of the Leading Edge of Ice Covers on Open Channel Flows, Ben Yao Hewlett, *M.S. Thesis*, Univ. of Iowa, July 1976.

061-10367-860-00

SUBJECT REVIEW FOR STATE-OF-THE-ART OF THE METHODS THAT CONSIDER RISK OR RELIABILITY IN THE DESIGN OR OPERATION OF RESERVOIR SYSTEM

(*b*) Institute of Hydraulic Research, University of Iowa.
(*c*) Dr. Thomas E. Croley II.
(*d*) Theoretical, applied research; graduate thesis.
(*e*) This study is interested in the methods that consider risk or reliability in the design or operation of single or multiple reservoir systems. The relevant literature is reviewed and critical assessments of these methods and of the state-of-the-art of the development and application of these methods are made. There are several types of uncertainties that contribute to the risk in reservoir design or operation. The efforts of this study focus on the basic uncertainty inherent in the natural stochastic processes involved in the design or operation of a reservoir system.
(*g*) Up to now, about fifteen methods concerning the risk in reservoir design or operation have been reviwed, from the earlier Moran's storage theory to the recent operation research approaches. Most of these methods are illustrated with a practical example; however the applicability of them is limited by their assumptions.

061-10368-810-33

URBAN GROWTH, RUNOFF, EXTERNALITIES AND INCOME DISTRIBUTION EFFECTS IN RALSTON CREEK WATERSHED

(*b*) U.S. Dept. of the Interior, Office of Water Research and Technology, Iowa State Water Resources Research Institute.
(*c*) Dr. Thomas E. Croley, Institute of Hydraulic Research and Dr. Jerald R. Barnard, Institute for Economic Research.
(*d*) Applied research; Doctoral thesis.
(*e*) Urbanization–induced flood hazard estimates are desired for Ralston Creek in Iowa City, Iowa. A deterministic watershed model and a stochastic precipitation model are used to circumvent the problem of nonstationarity induced in stream flow records by urbanization. By utilizing backwater analyses for the creek to estimate the probability of flooding for each residential property, the impact of flood hazard can be estimated using an econometric model of property values.
(*g*) A very efficient hourly precipitation data generation model for Ralston Creek area was developed. Point flooding frequency and flooding magnitude for different urban conditions is estimated for recurrence intervals up to 1000 years by using the precipitation and watershed models. The analysis of the property market indicated that flood hazard has a negative impact on property value.
(*h*) **Physical and Economic Aspects Associated with Runoff from Urban Growth: A Methodological Approach,** J. R. Barnard, T. E. Croley II, *Proc. Natl. Symp. Urban Rainfall and Runoff and Sediment Control*, Univ. Kentucky, Lexington, Ky., July 29-31, 1974.
Scheduling of Non-Stationary Hourly Precipitation, R. N. Eli II, T. E. Croley II, *Proc. Natl. Symp. Precipitation Analysis for Hydrologic Modeling*, Univ. California, Davis, Calif., June 26-28, 1975.
Increased Runoff from Urban Growth and Its Impact on Property Values, J. R. Barnard, *J. Economics Proc. of Missouri Valley Economics Assoc.* 2, pp. 133-136, Feb. 1976.
Ralston Creek Flooding Induced by South Branch Urbanization, T. E. Croley, J. R. Barnard, *Proc. Natl. Symp. Urban Rainfall and Runoff and Sediment Control*, Univ. Kentucky, Lexington, Ky., July 26-28, 1976.
An Hourly Precipitation Model for Ralston Creek, R. N. Eli II, T. E. Croley II, *Iowa Inst. Hydr. Res. Tech. Rept. No. 192*, Aug. 1976.
Externalities from Urban Growth: The Case of Increased Runoff and Flooding, J. R. Barnard, *Institute for Economic Research*, Univ. of Iowa, Oct. 1976.
Increased Runoff and Flooding from Urban Growth, J. R. Barnard, T. E. Croley II, *Institute for Economic Research*, Univ. of Iowa, Dec. 1976.
Economic Costs Associated with Increased Flood Hazard from Urban Growth, J. R. Barnard, *Institute for Economic Research*, Univ. of Iowa, Mar. 1977.

061-10369-340-33

OPTIMUM COMBINATION OF COOLING ALTERNATIVES FOR WATER AND FUEL ECONOMIES OF ELECTRIC POWER PLANTS

(*b*) Office of Water Research and Technology, U.S. Dept. of the Interior.
(*c*) Dr. Thomas E. Croley II.
(*d*) Theoretical; applied research; Doctoral thesis.
(*e*) It has been demonstrated that water and fuel consumption in electric power plants will increase at an alarming rate if the projected growth of the power industry is realized in the years to come. Although the water and fuel requirements of a power plant are closely related to the type of cooling system used, present cooling system designs do not take adequate account of the operating costs which are primarily water and fuel consumption. Furthermore, combinations of cooling systems now in use are based on ad hoc considerations of the recent environmental legislation rather than on detailed analysis of the water and fuel economies during operation. In the national interest, consideration of water and fuel economy as well as the adverse environmental aspects of open-cycle cooling will undoubtedly lead to increased popularity of alternative cooling system combinations. The research provides a basis for the proper selection of cooling systems and their combinations at the preliminary design stage. The approach taken is to systematically evaluate the various cooling systems and their combinations and identify the most promising ones. Computer optimization models are constructed for each alternative and for the various combinations utilizing standard thermodynamic models, capital costs, fuel and water costs, turbine characteristics, modes of operation and loading, meteorological conditions, size of power plant, and fogging and other environmental constraints.
(*g*) A comprehensive computer code has been developed for the assessment of the economics of various types of combination cooling systems for electric power plants. The model considers the basic thermodynamics of evaporative heat transfer, steam turbines, and condensers. The influence of different power loading patterns and changing meteorological conditions, as well as the various economic parameters is studied. The computer models have been used to investigate the thermodynamic and economic performance of several wet cooling tower-cooling pond configurations.

061-10370-870-73

AN INVESTIGATION OF THE HEAT TRANSFER AND ASSIMILATION CAPACITIES OF THE MISSISSIPPI AND MISSOURI RIVERS IN THE MAPP GEOGRAPHICAL AREA

(*b*) Mid-Continent Area Power Pool (MAPP), Minneapolis, Minn.
(*c*) Dr. J. F. Kennedy.
(*d*) Analytical investigation.
(*e*) A computer-based numerical model has been developed to predict the thermal regimes of rivers under variable climatic conditions, thermal input rates, and flow conditions. The model can be applied to any practical river situation for temperature predictions. The model was applied to predict the seasonal thermal regimes of the Mississippi and Missouri Rivers lying in and adjacent to the MAPP geographical area.
(*f*) Completed.
(*h*) **A Computational Model for Predicting the Thermal Regimes of Rivers,** P. P. Paily, J. F. Kennedy, *Iowa Inst. Hydr. Res. Tech. Rept. No. 169*, Nov. 1974.
The Thermal Regimes of the Upper Mississippi and Missouri Rivers, P. P. Paily, T. Y. Su, A. R. Giaquinta, J. F. Kennedy, *Iowa Inst. Hydr. Res. Tech. Rept. No. 182*, Oct. 1976.

Selected Appendices to IIHR Report No. 182: The Thermal Regimes of the Upper Mississippi and Missouri Rivers, P. P. Paily, T. Y. Su, A. R. Giaquinta, J. F. Kennedy, *Iowa Inst. Hydr. Res. Limited Dist. Rept. No. 47*, Oct. 1976.
Thermal Regimes of Upper Mississippi and Missouri Rivers and Hybrid Once-Through-Wet Tower Cooling Systems for Power Plants, T. Y. Su, *Ph.D. Thesis*, Univ. of Iowa, May 1977.
Cooling Water Resources of Upper Mississippi River for Power Generation, P. P. Paily, T. Y. Su, A. R. Giaquinta, J. F. Kennedy, *Proc. Conf. on Waste Heat Management and Utilization*, Miami Beach, Fla., May 9-11, 1977.

061-10371-870-33

DEVELOPMENT OF A COMPREHENSIVE, COMPUTER-BASED, NUMERICAL MODEL OF THE THERMAL REGIMES OF THE MISSISSIPPI AND MISSOURI RIVERS

(*b*) Office of Water Research and Technology, U.S. Dept. of the Interior; Iowa State Water Resources Research Institute.
(*c*) Dr. A. R. Giaquinta.
(*d*) Theoretical, applied research; Master's thesis.
(*e*) The steady-state Iowa Thermal Regime Model is used to compute the thermal regimes of the Mississippi River from Keokuk, Iowa, to the mouth and the Missouri River from the southern Iowa border to its confluence with the Mississippi River. This model, based on the steady one-dimensional heat equation, includes the effects of hydrological and meteorological variables on the heat transfer across the river surface. Temperature distributions downstream from each existing and proposed future power plant using once-through cooling are predicted for a range of meteorological and hydrological conditions. The most desirable sites for future once-through-cooled power plants are identified in terms of river heat assimilation capacity determined in light of existing thermal standards.

061-10372-700-11

AN IMPROVED MODEL OF THE IOWA SEDIMENT CONCENTRATION ANALYZER

(*b*) U.S. Army Corps of Engineers, Coastal Engineering Research Center.
(*c*) Dr. John R. Glover.
(*d*) Experimental.
(*e*) Redesign of the electronic circuits for both the light source and sensor was required to improve the frequency response characteristics of the system. With the prior instrument, particle velocity was limited to a maximum of 1/3 m/s without error both in the mean measurements and estimates of the mean square fluctuations of sediment concentration.
(*g*) The improved frequency response was accomplished by increasing the light source frequency to 50 kHz, raising the cutoff frequency of the high-pass filter blocking the dc component of the light detected to 25 kHz, and changing the Butterworth filter in the detector to a Bessel filter with a cutoff frequency of 2.5 kHz. Simulated particle tests indicate that mean measurements are unaffected by particle velocities as high as 8 m/s, and that fluctuations are correctly reproduced for particles with velocities less than 3 m/s.
(*h*) **Characteristics of Iowa Sediment Concentration Measuring System,** T. Nakato, F. A. Locher, J. R. Glover, J. F. Kennedy, *Proc. of 15th Intl. Conf. on Coastal Engrg.*, Honolulu, Hawaii, July 1976.

061-10373-310-33

FLOOD CONTROL MANAGEMENT IN SEDIMENTING RESERVOIRS SUBJECT TO RECREATION DEMANDS

(*b*) Office of Water Research and Technology, U.S. Dept, of the Interior; Iowa State Water Resources Research Institute.
(*c*) Dr. Thomas E. Croley II.
(*d*) Theoretical, applied research, operation, development; Doctoral thesis.
(*e*) A present conflict exists on the Coralville reservoir near Iowa City, Iowa, between recreation users and the managing agency of the reservoir. The research considered various operation management plans to determine operations whereby both the flood control and the recreation interests can be served with minimum conflict. Consideration was given to operation rules, recreation demands, flood occurrences, flood consequences, reservoir use, inflows, outflows, evaporation, other relevant hydrological time series, and the dynamic reservoir characteristics. Computer models were constructed to detail the reservoir sedimentation, the reservoir profile changes, and the consequent routing characteristic changes. Stochastic models of all relevant input time series were used to construct probability statements for levels of attainment of various objectives. The study analyzed different operation plans so that a "best" operation plan was designed. The choice of an operation plan was based upon separate objective fulfillments for a multipurpose reservoir without resorting to assignment of a common measure to all objectives (such as dollars), or reduction of some objectives to operation constraints. The models and the techniques for modeling and analysis were generally formulated allowing for their use in other multiple-objective applications.
(*f*) Completed.
(*g*) The stochastic trade-off methodology developed in this study enables the estimation of risks or probabilities associated with achievement of various levels of a reservoir operation objective while maintaining minimum levels of another operation objective. Trade-offs are constructed by maximizing benefits with respect to one objective with the constraint that minimum levels of benefits also must be realized with respect to other objectives. By repeating the optimization for many constraint levels, the trade-off function between objectives is constructed.
The Coralville reservoir was originally designed and is currently being operated as a flood-control reservoir. At the present time there is conflict between recreation users and the operating agency. The former demand enhancement of recreation opportunities and consequent higher and consistent pool levels, and the latter maintain that the reservoir was originally designed for flood control and that any deviation from current operation plans will impair flood control benefits. This study evolves operation plans, based on selected objective trade-offs and risks between flood control and recreation objectives.
The existing and the evolved operation rules are tested in a comprehensive reservoir model which adjusts the reservoir profile for sediment distribution, deposition, and recompaction of all sediment layers biannually. The model reflects the influence of the reservoir profiles, sediment consistency, evaporation, inflows, and reservoir operations. The model is used to simulate the behavior of the reservoir for the next ten years and calculations of reservoir sedimentation, flood control benefits, and recreation use are made. The evolved operation rules are shown to provide more flood control and recreation benefits than the existing operation rule without increasing sedimentation rates.
(*h*) **Quantification of Recreational Use of the Coralville Reservoir,** T. E. Croley II, R. Chen, *Iowa Inst. Hydr. Res. Tech. Rept. No. 181*, Aug. 1975.
Iowa River Flood Damage Related to Coralville Reservoir Operations, T. E. Crolwy II, F. Karim, *Iowa Inst. Hydr. Res. Tech. Rept. No. 194*, Oct. 1976.
Reservoir Sedimentation Calculations Using Continuing Distribution, Recompaction and Sediment Slump, T. E. Croley II, K. N. R. Rao, *Iowa Inst. Hydr. Res. Tech. Rept. No. 198*, 1977.
Hydrologic Time Series Deseasonalization and Reconstruction, T. E. Croley II, K. N. R. Rao, *Iowa Inst. Hydr. Res. Tech. Rept. No. 199*, 1977.
Stochastic Trade-Offs for Reservoir Operation, T. E. Croley II, K. N. R. Rao, *Iowa Inst. Hydr. Res. Tech. Rept. No. 197*, Jan. 1977.

Adaptive River Basin Management with Single or Multiple Objectives, T. E. Croley II, *Proc. XVIth Congress, Intl. Assoc. for Hydr. Res.*, Sao Paulo, Brazil, July 27-Aug. 1, 1975.
Multipurpose Reservoir Operation Using Stochastic Trade-Off Analyses, T. E. Croley II, K. N. R. Rao, *Proc. 2nd Intl. Symp. Stochastic Hydraulics*, Lund, Sweden, Aug. 2-4, 1976.

061-10374-340-61

OPTIMUM MECHANICAL DRAFT WET COOLING TOWERS TO SUPPLEMENT ONCE-THROUGH COOLING AT SELECTED MISSOURI RIVER SITES

(*b*) Iowa State Water Resources Research Institute; Office of Water Research and Technology, U.S. Dept. of the Interior.
(*c*) Dr. Thomas E. Croley II.
(*d*) Analytical, applied and basic research; Ph.D. thesis.
(*e*) To construct necessary computer-based, numerical models and methodology for determining the most economical size of mechanical draft wet cooling tower for use as a "helper" to once-through cooling for utilities on the Missouri River.
(*g*) Thermodynamic and economic models of combined mechanical draft wet cooling towers and once-through cooling systems have been developed. The search for the most economical arrangement and operation mode of the combined cooling system was carried out with two configurations: open-cycle parallel arrangement and partially closed-cycle parallel arrangement. Each system was analyzed by incorporating it in a proposed future unit (rated capacity of 1150 MW) along the Missouri River at Fort Calhoun, Nebraska. Capital and operating costs of the two configurations were determined for condensers having flow rates of 900,000 gpm and 585,000 gpm. From the cases studied it is seen that the minimum unit cost of energy production results from a combined cooling system with an 1100 ft cooling tower operating in a partially closed-cycle mode with the smaller condenser. However, the economy of this mode of operation is partially offset by the disadvantage of greater water losses.

061-10375-870-73

COOLING WATER DISCHARGE THERMAL-HYDRAULIC MODEL, ST. LUCIE NUCLEAR POWER PLANT

(*b*) Florida Power and Light Company, and Ebasco Services Inc., New York.
(*c*) Dr. S. C. Jain and Dr. J. F. Kennedy.
(*d*) Experimental, applied and basic research.
(*e*) Various thermal and hydraulic model tests were performed in connection with the design and performance of the offshore thermal outfalls for St. Lucie Nuclear Power Plant. These tests included model investigations of (i) the multiple-port discharges of Unit II, (ii) the submerged Y-outlet discharge for unit I, (iii) hydraulic characteristics for Y-nozzle and discharge ports.
(*f*) Completed.
(*g*) On the basis of thermal-hydraulic model tests, it was found that a multiport diffuser with 58 discharge nozzles aimed offshore at >25° from the pipe axis would meet the thermal criterion. The momentum of the discharge produces an off-shore drift of the diluted warm-water plume.
(*h*) **Investigation of the Thermal Near-Field for an Alternating Multiport Diffuser Pipe**, A. Nospal, *M.S. Thesis*, Univ. of Iowa, Dec. 1974.
Cooling Water Discharge Thermal-Hydraulic Characteristics Model of the St. Lucie Nuclear Power Plant, S. C. Jain, J. F. Kennedy, *Iowa Inst. Hydr. Res. Tech. Rept. No. 176*, July 1975.

061-10376-870-75

HYDRO-THERMAL MODEL STUDY OF THE KAHE POWER PLANT CONDENSER WATER DISCHARGE SYSTEM

(*b*) Bechtel, Inc., San Francisco, California.
(*c*) Dr. S. C. Jain and Dr. J. F. Kennedy.
(*d*) Experimental, applied and basic research.
(*e*) Various model tests were performed in connection with the design of the outfall structure for the condenser cooling water discharge for the Kahe Power Plant.
(*f*) Completed.
(*g*) The recommended discharge structure consists of two 12-ft diameter pipes, each terminating with an 11-ft diameter nozzle discharging offshore at an angle of 20° above the horizontal. The nozzles will be located at water depth of 27 ft below MLLW.
(*h*) **Preliminary Report–Thermal-Hydraulic Model Study of Offshore Discharge System of Kahe Power Plant**, S. C. Jain, *Iowa Inst. Hydr. Res. Limited Dist. Rept. No. 38*, Jan. 1976.
Thermal-Hydraulic Model Study of Offshore Discharge System for Kahe Power Plant, Hawaii, S. C. Jain, M. Leonard, J. F. Kennedy, *Iowa Inst. Hydr. Res. Tech. Rept. No. 184*, Jan. 1976.

061-10377-410-13

EVALUATION OF MOVABLE BED TIDAL INLET MODELS

(*b*) Coastal Engineering Research Center.
(*c*) Dr. S. C. Jain and Dr. J. F. Kennedy.
(*d*) Theoretical, applied and basic research.
(*e*) The results of movable bed tidal inlet hydraulic model studies conducted by Waterways Experiment Station were compared with the observation made in the prototype to evaluate the effectiveness of such models.
(*g*) Some quantitative indications, including correlation coefficients and root-mean-square error are used to check the accuracy of model performance.
(*h*) **Evaluation of Movable Bed Tidal Inlet Models**, S. C. Jain, J. F. Kennedy, *Proc. 15th Coastal Engrg. Conf., Honolulu, Hawaii*, June 1976.

061-10378-870-73

HYDRAULIC MODEL TESTING FOR LAKE ERIE GENERATING STATION

(*b*) Envirosphere Company, a Division of Ebasco Services, New York, and Niagara Mohawk Power Corporation, Syracuse, New York.
(*c*) Dr. S. C. Jain.
(*d*) Experimental, applied research.
(*e*) Various thermal-hydraulic model tests were performed in connection with the blowdown discharge structure for the blowdown discharge of the cooling tower at the propsoed Lake Erie Generating Station.
(*f*) Completed.
(*g*) On the basis of thermal hydraulic model tests, a diffuser with alternative nozzles was recommended.
(*h*) **Hydraulic-Thermal Model Study of the Blowdown Discharge of the Lake Erie Generating Station**, S. C. Jain, *Iowa Inst. Hydr. Res. Limited Dist. Rept. No. 41*, June 1976.

061-10379-870-73

PREDICTION AND MODELING NEAR FIELD BEHAVIOR OF MECHANICAL DRAFT COOLING TOWER PLUMES

(*b*) Electric Power Research Institute.
(*c*) Dr. S. C. Jain and Dr. J. F. Kennedy.
(*d*) Experimental and theoretical, basic and applied research.
(*e*) This research program is to develop techniques for small scale model tests of cooling tower installations which will provide relatively complete data on near field characteristics of the plumes and their effects on cooling tower performance and to validate model testing as a reliable means of plume prediction for use in resolving questions and guiding decisions related to power plant siting and layout.

061-10380-870-73

THERMAL-HYDRAULIC MODEL STUDY OF THE COOLING WATER DISCHARGE FROM NPPD'S GERALD GENTLEMEN STATION INTO SUTHERLAND RESERVOIR

(*b*) Nebraska Public Power District, Columbus, Nebraska.
(*c*) Dr. S. C. Jain and Dr. J. F. Kennedy.
(*d*) Experimental, applied research.
(*e*) Near field mixing characteristics of the thermal discharge from the auxiliary cooling pond and Sutherland Reservoir were investigated.
(*g*) Near field dilution was found to be not sensitive to jet densimetric Froude number for the discharge studies tested in the model.

061-10381-010-14

THREE-DIMENSIONAL BOUNDARY LAYERS AND THE ORIGIN OF LIFT ON BODIES OF REVOLUTION AT INCIDENCE

(*b*) U.S. Army Research Office and Lockheed-Georgia Co.
(*c*) Dr. V. C. Patel.
(*d*) Experimental and theoretical, basic research; graduate theses.
(*e*) The objective of this research is to make an experimental and theoretical study of the behavior of the boundary layer on bodies of revolution at incidence. The study has relevance to the design of aircraft fuselages, missiles, and underwater vehicles and is expected to yield information necessary for the prediction of forces on such shapes.
(*g*) The study has been organized into two phases. The first of these involves the development of a suitable three-dimensional boundary-layer calculation procedure. A computer program has been developed for calculating potential flow past an arbitrary inclined body of revolution. A finite-difference program for the calculation of the three-dimensional boundary layer on the surface is under development. The second phase of the project involves an experimental study of the three-dimensional boundary layer. As a preliminary to detailed measurements, flow visualization studies over different bodies of revolution were carried out in a large water flume and later in a wind tunnel. Colored dyes were used to observe the surface flow patterns in the flume, while wool tufts glued on the body surface were used in the wind tunnel experiments. These flow visualization studies served to provide an understanding of some of the basic features of three-dimensional flows such as separation, flow reversal, vortex roll-up, etc. These experiments also provided the necessary information for the design of a suitable body shape which will be used for detailed tests in the large wind tunnel of the Institute. A 4-ft long × 1-ft maximum diameter hemisphere-spheroid body, fully instrumented for boundary layer studies, is presently being fabricated for these wind tunnel tests.
(*h*) **Advances in Turbulent Boundary Layer Calculation Methodology,** J. F. Nash, V. C. Patel, *Proc. of Penn State Univ. Symp. Turbulent Shear Flows*, pp. 5.1-11, 1977.

061-10382-340-36

ENGINEERING AND ECONOMIC ASSESSMENT OF BACKFITTING POWER PLANTS WITH CLOSED-CYCLE COOLING SYSTEM

(*b*) U.S. Environmental Protection Agency.
(*c*) T. E. Croley II and V. C. Patel.
(*d*) Experimental, design.
(*e*) Investigation of the engineering and economic (including environmental) consequences of backfitting a steam-electric power plant (both fossil and nuclear fueled) with four closed-cycle cooling systems: mechanical draft evaporative towers, natural draft evaporative towers, cooling ponds, and spray canals.
(*f*) Completed.
(*g*) Development of computational models for several closed-cycle cooling systems which allow economic consideration of sizing. Examples illustrating analysis of each type of cooling system are shown.
(*h*) **Economic Assessment of Backfitting Power Plants with Closed-Cycle Cooling Systems,** A. R. Giaquinta, T. E. Croley II, V. C. Patel, J. G. Melville, M. S. Cheng, A. S. Uzuner, *Rept. No. EPA-600-2-76-050, U.S. Environmental Protection Agency*, Research Triangle Park, N.C., Mar. 1976. Available from NTIS.

061-10383-290-14

COMPRESSIBLE RECOIL MECHANISM

(*b*) Army Research Office.
(*c*) Dr. C. J. Chen.
(*d*) Experimental and theoretical, basic; graduate theses.
(*e*) Study of unsteady laminar and turbulent flow in shock-absorbing system.

061-10384-190-15

FRAZIL ICE FORMATION IN TURBULENT FLOW

(*b*) Cold Regions Research and Engineering Laboratory, U.S. Army Corps of Engineers, Hanover, New Hampshire.
(*c*) Dr. J. F. Kennedy.
(*d*) Experimental, applied research; Doctoral thesis.
(*e*) The criteria for establishing design standards for structures that must pass super-cooled water and frazil ice (namely hydro-electric and municipal intakes and possibly nuclear cooling systems) are not firmly established. Frazil ice can form in water which is supercooled only to a few hundredths of a degree Celsius below zero. These frazil ice particles initially form as small discs, apparently throughout the fluid and collect on the water surface forming what appears to be snow slush. Heavy concentrations can block intake structures and even form ice jams in rivers due to its adhesive capabilities during the growth stage of the crystals. An experimental apparatus has been designed to study systematically the formation of frazil ice under controlled laboratory conditions. The development of reliable predictors for frazil ice formation based on the rate of water supercooling, degree of turbulence, the associated heat transfer at the particle-fluid interface, and the presence of foreign impurities will be studied.
(*g*) Preliminary results have shown that impurities such as silt or sand have no noticeable effect in the formation of frazil ice. The major ingredient necessary for frazil ice formation is the presence of ice crystals to trigger the nucleation process. In rivers these ice crystals will be present in the shore ice that forms first along the banks and in pools, and in the splash zone of high velocity rapid reaches provided that cold air temperatures are present.

061-10385-030-70

POTENTIAL FLOW AROUND CIRCULAR COOLING TOWERS

(*b*) The Marley Company.
(*c*) Dr. J. C. Tatinclaux and Dr. L. Landweber.
(*d*) Theoretical, applied research.
(*e*) Development of a mathematical model for calculating air flow patterns for an array of round cooling towers. Viscous effects are neglected and the intake through the periphery of each tower is known. Each tower can then be represented by a distribution of singularities and the corresponding flow potential determined. The corresponding flow field can be calculated.
(*f*) Completed.
(*g*) Two mathematical models for the flow around a round mechanical draft cooling tower, either isolated or part of an array of towers, in a uniform ambient wind have been derived. The first one takes into consideration the effect of exhaust flow through the tower stack and the influence of the ambient wind on the magnitude and distribution of an intake around the periphery of the tower which the second, simpler model neglects. Examples of application are presented.
(*h*) **Mathematical Model of the Flow About a Circular Cooling Tower,** J. C. Tatinclaux, B. Y. Ting, L. Landweber, *Iowa Inst. Hydr. Res. Limited Dist. Rept. No. 40*, Apr. 1976–revised Apr. 1977.

Flow Around Circular Cooling Towers–Effect on Plume Rise, *Iowa Inst. Hydr. Res. Limited Dist. Rept. No. 46*, Mar. 1977.

061-10386-340-70

PLUME RECIRCULATION AND INTERFERENCE IN MECHANICAL DRAFT COOLING TOWERS

(*b*) The Marley Company.
(*c*) Dr. S. C. Jain.
(*d*) Experimental; Master's thesis.
(*e*) Model studies are being conducted on small scale models of various types of mechanical draft cooling towers to determine the trajectories of the plumes they produce and the interaction between the plumes and the tower from which it originates, as well as downwind towers. The experiments are being conducted in a specially designed flume which is 10 ft wide, 60 ft long, and 7.5 ft deep. Modeling is based on kinematical similarity and on equality of the densimetric Froude number in model and prototype. Buoyancy is achieved by heating or cooling the stack effluent. Ambient fluid is withdrawn into the intake faces of the tower. The recirculation ratio (the fraction of stack effluent in the tower's ingested fluid) and plume configuration are determined from temperature measurements made with thermistor banks interfaced with an on-line computer.
(*g*) Experiments have been conducted for densimetric Froude numbers (based on the stack effluent velocity and the stack diameter) from 2 to 7, and ratios of jet ambient velocity of 0.4 to 12. Rectangular, circular, and annular towers of different overall dimensions and with different stack heights and spacing have been investigated. Experiments have also been made for wet-dry towers. It was found that recirculation generally increases with decreasing Froude number for negative buoyancy plumes and with increasing Froude number for positive buoyancy plumes. With increasing velocity ratio the recirculation ratio generally decreases for positive buoyancy plumes; for negative buoyancy plumes recirculation first decreases then increases with velocity ratio. Increasing stack height and spacing both reduce the recirculation. The plume configuration is slightly sensitive to the densimetric Froude number in the range investigated, and is strongly affected by the velocity ratio. Round towers have much lower recirculation ratios than rectangular ones. The recirculation ratio for a two-tower system, with a second tower directly downwind from the first, is relatively insensitive to Froude number, but decreases markedly with increasing velocity ratio. For the case of a single rectangular tower, the recirculation ratio of the downwind face of a six-stack tower oriented at 90° to the ambient wind ranges from about 2 to 12 percent, while for a single circular tower the recirculation ratio is always less than about 2 percent. The recirculation ratio of the downwind tower of two 12-stack towers spaced half a tower length apart can be as great as 20 percent. Very large recirculation ratios frequently occur when the wind is nearly aligned with the tower axis; in this case the cross wind deflects the plume over the whole tower resulting in very large ingestion of stack effluent.
(*h*) **Plume Recirculation and Interference in Mechanical Draft Cooling Towers,** J. F. Kennedy, H. Fordyce, presented *Symp. Cooling Tower Environment–1974*, Univ. of Maryland, Mar. 4-6, 1974.
Plume Recirculation and Interference in Mechanical Draft Cooling Tower, T.-L. Chan, S.-T. Hsu, J.-T. Lin, H.-H. Hsu, N.-S. Huang, S. C. Jain, C. E. Tsai, T. E. Croley II, H. Fordyce, J. F. Kennedy, *Iowa Inst. Hydr. Res. Tech. Rept. No. 160*, Apr. 1974.

061-10387-220-05

SEDIMENT DISCHARGE OF ALLUVIAL STREAMS CALCULATED FROM BED-FORM STATISTICS

(*b*) Dept. of Agriculture, Agriculture Research Service; and Iowa Institute of Hydraulic Research.
(*c*) Dr. J. C. Willis and Dr. J. F. Kennedy.
(*d*) Experimental and theoretical; Ph.D. thesis.
(*e*) The total sand load of a stream is being treated as the sum of two parts: that contributed by the downstream migration of the bed forms as "dune load"; and that carried over the separation zones of the troughs and above the bed as suspended load. The overall objective of this study is to develop methods for calculating these sediment loads from concepts closely related to the physical transport processes involved. Other related objectives are to define the various functions used in the calculational procedure and to relate the parameters of the functions to measureable flow variables.
(*g*) The dune load has been derived as a sum of contributions by the Fourier frequency components of bed-elevation records. These sine or cosine waves are characterized by amplitudes proportional to their contribution to the standard deviation of the bed surface and migration velocities calculated from cross-spectral phase angles between dual records of bed elevation. The contribution to the standard deviation is obtained by differentiating the variance contribution defined as the spectral density function of the bed surface. The distribution of the flux of sediment transport over the flow depth has been derived from published models of velocity and concentration distributions. The suspended load is calculated from the integral of the flux distribution for our reference concentrations based on the effective bed concentration. This effective bed concentration is defined as the product of bulk density of the bed material and the fraction of the time or distance during which the bed surface remains above the reference level. New data from a series of laboratory flume experiments with equilibrium flows and bed forms are being used to supplement existing data and to define the various functions and parameters entering the load calculations. These data include temporal and spatial elevation records for different flow rates and water temperatures. Total load measurements provide a check of the load calculations and aid in developing the empirical aspects of the calculational procedure.
(*h*) **Sediment Discharge of Alluvial Streams Calculated from Bed-Form Statistics,** *Ph.D. Thesis*, Mechanics and Hydraulics Program, Univ. of Iowa, Dec. 1976.
Sediment Transport in Stochastic Bed Forms, J. C. Willis, J. F. Kennedy, manuscript under preparation.

061-10388-200-00

FLOW IN ALLUVIAL CHANNEL BENDS

(*b*) Institute of Hydraulic Research.
(*c*) M. Falcón and Dr. J. F. Kennedy.
(*d*) Theoretical; Ph.D. thesis.
(*e*) An analytical model is being developed to describe the spatial distributions of water- and sediment-transport quantities of flows in irregular meandering channels. The analytical scheme is based on the balance of torque resulting from channel curvature and vertical nonuniformity of the mean-velocity distribution; torsional inertia of the water mass; and boundary shear acting in radial planes perpendicular to the channel axis.
(*g*) An improved model has been developed to describe the cross-sectional distribution of radial velocities in channel-bend flows. It has been found that for flows in typical river bends the Coriolis force is small but still not negligible in evaluating the streamwise momentum balance.
(*h*) **Transverse Bed Slopes in Alluvial Streams,** C. Zimmermann, J. F. Kennedy, submitted to ASCE, Mar. 1976.

061-10389-010-00

OSCILLATING BOUNDARY LAYER

(*b*) Institute of Hydraulic Research.
(*c*) Dr. B. R. Ramaprian.
(*d*) Experimental, basic research.
(*e*) The project involves an experimental study of a transitional boundary layer in the presence of a sinusoidally oscillating free stream. The boundary-layer velocity measurements are made using laser-Doppler anemometry. This study forms the initial effort to understand the effect of flow unsteadiness on turbulent shear flows. The study has

important applications in the areas of helicopter and missile aerodynamics.

(*g*) Measurements made so far indicate the following important features: (i) the flow close to the wall leads the outer flow while the flow in the middle region of the boundary layer slightly lags behind the outer flow; (ii) significant amount of random motion exists near the wall in the neighborhood of the maximum velocity during the cycle.

061-10390-000-00

AN EXPERIMENTAL STUDY OF PULSATILE FLOW IN A ROUND TUBE AT LOW REYNOLDS NUMBER

(*b*) University of Iowa.
(*c*) Dr. B. R. Ramaprian.
(*d*) Experimental, basic research; Master's thesis.
(*e*) The project involves an experimental study of sinusoidally oscillating flow in a round tube at transitional Reynolds number. Laser-Doppler anemometry will be used to measure the periodic and random components of the velocities in the pulsating flow. The study is of immediate relevance to biofluid flow problems such as arterial blood flow. However, the experimental data are expected to contribute to the basic understanding of the effect of flow unsteadiness on the structure of turbulent shear flows.

061-10391-010-70

MEAN FLOW MEASUREMENTS IN THE THREE-DIMENSIONAL BOUNDARY LAYER OVER A BODY OF REVOLUTION AT INCIDENCE

(*b*) Lockheed Co., Marietta, Georgia.
(*c*) Dr. B. R. Ramaprian.
(*d*) Experimental, basic research; Doctoral thesis.
(*e*) The project involves the measurement of the mean velocity and flow angles in the three-dimensional boundary layer over a body of revolution placed at an angle of incidence to the free stream. The measurements will be made using a three holed yaw-probe. Boundary-layer measurements will be made at several longitudinal and circumferential locations of the body. These measurements are expected to be useful in the development/calibration of calculation methods for three-dimensional boundary layers.

061-10392-030-54

AERODYNAMICS OF HYPERBOLIC COOLING TOWERS

(*b*) National Science Foundation.
(*c*) Dr. C. Farell.
(*d*) Experimental and theoretical; basic and applied research; graduate theses.
(*e*) The influence of distributed and rib-type roughnesses on the mean pressure distributions on circular cylinders and hyperbolic cooling tower models was investigated. The major aims of the study were to assess the beneficial effects of surface roughness on wind loading, to identify criteria for the modeling of prototype conditions in wind-tunnel tests, and to develop a method for predicting the wind loads on prototype structures fitted with different types and sizes of roughness. Empirical corrections for wind-tunnel blockage effects have been developed. The analytical results include a simple model for two-dimensional mean flow at very large Reynolds numbers around a circular cylinder with distributed roughness, and calculations of boundary layer development over a ribbed cylinder.
(*h*) **Wind Loading on Hyperbolic Cooling Towers,** F. Maisch, *M.S. Thesis*, Univ. of Iowa, July 1974.
External Roughness Effects on the Mean Wind Pressure Distribution on Hyperbolic Cooling Towers, C. Farell, F. Maisch, *Iowa Inst. Hydr. Res. Tech. Rept. No. 164*, Aug. 1974.
Effect of Wind Tunnel Walls on the Flow About Circular Cylinders and Cooling Towers, S. Carrasquel, *M.S. Thesis*, Univ. of Iowa, Sept. 1974.
Surface Roughness Effects on the Mean Flow Past Circular Cylinders, O. Güven, V. C. Patel, C. Farell, *Iowa Inst. Hydr. Res. Tech. Rept. No. 175*, May 1975.
Wind Loading on Hyperbolic Cooling Towers, C. Farell, O. Güven, F. Maisch, V. C. Patel, *Proc. 2nd U.S. Natl. Conf. on Wind Engrg. Research*, Colorado State Univ., Fort Collins, Colo., June 1975.
An Experimental and Analytical Study of Surface-Roughness Effects on the Mean Flow Past Circular Cylinders, O. Güven, *Ph.D. Thesis*, Univ. of Iowa, Dec. 1975.
Laboratory Simulation of Wind Loading on Rounded Structures, C. Farell, O. Güven, V. C. Patel, *Proc., IASS World Congress on Space Enclosures*, Montreal, July 1976.
Mean Wind Loading on Rough-Walled Cooling Towers, C. Farell, O. Güven, F. Maisch, *J. Engrg. Mechanics Div., ASCE* **102,** EM6, pp. 1059-1081, Dec. 1976.
Flow Around Ribbed Cylinders: Experimental and Analytical Studies, C. Farell, V. C. Patel, O. Güven, presented *2nd Ann. ASCE Engrg. Mechanics Div. Specialty Conf.*, Raleigh, N.C., May 1977.

061-10393-030-54

MEAN AND FLUCTUATING PRESSURE DISTRIBUTIONS ON CIRCULAR CYLINDERS WITH LARGE ROUGHNESS

(*b*) National Science Foundation.
(*c*) Dr. C. Farell.
(*d*) Experimental and theoretical; basic and applied research; graduate theses.
(*e*) The effect of distributed roughness on the mean and fluctuating pressure distributions on circular cylinders is being investigated, with the aims of extending the theoretical understanding of the flow phenomena and obtaining quantification of results using up-to-date boundary-layer calculation procedures, and developing an interaction model to couple the boundary-layer and wake behavior with the external potential flow.

IOWA STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY, Department of Aerospace Engineering, Ames, Iowa 50011.

062-09792-480-54

LABORATORY AND NUMERICAL SIMULATION OF TORNADOES

(*b*) National Science Foundation.
(*c*) Professor C. T. Hsu.
(*d*) Experimental and theoretical; basic and applied; Master and Doctoral thesis.
(*e*) A unique facility was designed for simulating the interaction of a main vortex (tornado cyclone) with a ground plane. Numerical analysis was also being carried out for analyzing the flow field resulting from the interaction of a main vortex with a plane boundary.
(*g*) It was found that the interaction of the main vortex with a ground plane is responsible for the formation of a tornado funnel. High speed photography used to measure the instantaneous velocity components indicates that the radial distribution of tangential velocities at low levels is in good agreement with Hoecker's observation of the Dallas tornado. Pressure deficit measured at the vortex center ranges across the boundary layer from 1.5 to 4 times the values obtained from the conventional cyclostrophic relation. A new turbulence model, which consists of one differential equation for the turbulence energy and three empirical equations for the turbulent diffusivity, the rate of diffusion of the turbulence energy and the rate of viscous dissipation of turbulence energy was developed to further analyze the flow field of vortex and boundary interaction. Our preliminary result of the time dependent solutions indicates that a four-cell vortex may exist in the boundary layer. This result is in good qualitative agreement with observations from natural tornadoes as well as from our laboratory simulations.

(*h*) **Mechanism of Tornado Funnel Formation,** C. T. Hsu, B. Fattahi, *Physics of Fluids* **19,** 12, pp. 1853-57, Dec. 1976.
Turbulent Modeling of a Vortex Boundary Layer Flow, C. T. Hsu, H. Tesfamariam. To be published in *Mathematics and Computers in Simulation.*
Wind and Pressure Fields of a Tornado-Like Vortex, C. T. Hsu, B. Fattahi, Iowa State University, *ERI Report 77246,* 1977 (request from correspondent (c)).

062-09793-220-50

EOLIAN EROSION ON MARS

(*b*) NASA, Ames Research Center.
(*c*) Professor J. D. Iversen.
(*d*) Experimental, theoretical, basic research.
(*e*) Investigation of mechanism of solid particle entrainment due to strong winds, particularly at low atmospheric density, such as on Mars.
(*h*) **Windblown Dust on Earth, Mars, and Venus,** J. D. Iversen, R. Greeley, J. B. Pollack, *J. Atmospheric Sciences* **33,** pp. 2425-2429, 1976.
The Effect of Vertical Distortion in the Modeling of Sedimentation Phenomena; Martian Crater Wake Streaks, J. D. Iversen, *J. Geophysical Res.* **81,** pp. 4846-4856, 1976.
Eolian Erosion of the Martian Surface; Part I: Erosion Rate Similitude, J. D. Iversen, R. Greeley, B. R. White, J. B. Pollack, *Icarus* **26,** pp. 321-331, 1975.
Saltation Threshold on Mars; The Effect of Interparticle Force, Surface Roughness, and Low Atmospheric Density, *Icarus* **29,** pp. 381-393, 1976.

062-09794-540-50

AIRCRAFT TRAILING VORTICES

(*b*) NASA, Ames Research Center.
(*c*) Professor J. D. Iversen.
(*d*) Experimental, theoretical, applied research.
(*e*) Wind tunnel measurements of interacting and merging co-rotating vortices.
(*h*) **Merging of Aircraft Trailing Vortices,** S. A. Brandt, J. D. Iversen, *AIAA Paper 77-8,* 1977.
Merging Distance Criteria for Co-Rotating Trailing Vortices, J. D. Iversen, S. A. Brandt, P. Raj, *Proc. Aircraft Wake Vortices Conf.,* U.S. Dept. Transportation, Transportation Systems Center, Cambridge, Mass., 1977.
Inviscid to Turbulent Transition of Trailing Vortices, J. D. Iversen, *AIAA Paper 75-883,* 1975.
Correlation of Turbulent Trailing Vortex Decay Data, *J. of Aircraft* **13,** pp. 338-342, 1976.

IOWA STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY, Department of Agricultural Engineering, Ames, Iowa 50011. Dr. H. P. Johnson, Professor.

063-0017W-810-07

PHYSICAL AND ECONOMIC ANALYSIS OF WATERSHEDS

See Water Resources Research Catalog **9,** 6.0339.

063-0264W-870-33

MOVEMENT OF PESTICIDES AND NUTRIENTS WITH WATER AND SEDIMENT AS AFFECTED BY TILLAGE PRACTICES

See Water Resources Research Catalog **9,** 5.0658.

063-0265W-840-07

QUALITY OF TILE EFFLUENT

See Water Resources Research Catalog **9,** 5.0659.

IOWA STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY, Department of Engineering Science and Mechanics, Ames, Iowa 50011. Professor Donald F. Young.

064-07392-270-40

EFFECT OF STENOTIC OBSTRUCTIONS ON FLOW IN TUBES

(*b*) Iowa State Univ. Engr. Research Inst.; National Institutes of Health.
(*d*) Experimental and theoretical; basic research.
(*e*) Project is concerned with steady and unsteady flow of liquids through circular tubes which contain some type of constriction. Flow characteristics which may be of importance to blood flow through arteries containing stenoses are being studied. These include pressure distribution, laminar separation phenomena, transition Reynolds numbers for the initiation of turbulence, and turbulence. Both *in vitro* and *in vivo* tests are under consideration.
(*h*) **Pressure Drop Across Artificially Induced Stenoses in the Femoral Arteries of Dogs,** D. F. Young, N. R. Cholvin, A. C. Roth, *Circulation Research* **36,** pp. 735-743, 1975.
Wall Vibrations Induced by Flow Through Simulated Stenoses in Models and Arteries, R. L. Kirkeeide, D. F. Young, N. R. Cholvin, *Proc. 28th Ann. Conf. Engr. Med. and Biology,* p. 408, 1975.
Effect of Collateral and Peripheral Resistance on Blood Flow Through Arterial Stenoses, A. C. Roth, D. F. Young, N. R. Cholvin, *J. Biomechanics* **9,** pp. 367-375, 1976.
Effect of Geometry on Pressure Losses Across Models of Arterial Stenoses, B. D. Seeley, D. F. Young, *J. Biomechanics* **9,** pp. 439-448, 1976.
Effect of Elevated Flow Rates on Pressure Losses Across Arterial Stenoses, D. F. Young, N. R. Cholvin, R. L. Kirkeeide, A. C. Roth, *Proc. 11th Intl. Conf. Med. and Biol. Engr.,* pp. 334-335, 1976.

064-09020-000-00

OSCILLATING INCOMPRESSIBLE FLOW IN A TORUS

(*b*) Iowa State Univ. Engr. Research Institute.
(*c*) Dr. Bruce R. Munson.
(*d*) Theoretical, experimental; basic research.
(*e*) Investigation of the secondary flows within a coiled pipe or torus when the flow is driven by sinusoidal oscillations of the torus or by sinusoidal pressure gradient in a stationary torus. The qualitative and quantitative nature of the secondary flows generated are strongly dependent on the dimensionless frequency of oscillation.
(*g*) Secondary flow in an oscillating torus is directed from the outside of the bend toward the inside even at low frequencies of oscillation. This phenomenon is opposite to the outward centrifuging secondary flows for steady flow in a curved pipe or for flow driven by a slowly oscillating pressure gradient in a torus. Experimental results verify the perturbation theory solutions.
(*h*) **Secondary Flow in a Slowly Oscillating Torus,** B. R. Munson, *Phys. Fluids* **9,** 11, pp. 1823-1825, 1976.
Experimental Results for Oscillating Flow in a Curved Pipe, B. R. Munson, *Phys. Fluids* **19,** 12, pp. 1607-1609, 1975.

064-09021-000-00

FLOW IN A SPHERICAL ANNULUS

(*b*) Iowa State Univ. Engr. Research Inst.; National Science Foundation.
(*c*) Dr. Bruce R. Munson.
(*d*) Theoretical, experimental; basic research.
(*e*) Investigation of the basic laminar flow within the spherical annulus between two spheres rotating about a common axis. Investigation of the stability properties of spherical annulus flow and the transition to turbulence.
(*g*) Theoretical stability limits (critical Reynolds numbers) are obtained from linear hydrodynamic stability theory for the flow in a spherical annulus. Experimental and theoretical results show that the nature of transition from the basic

laminar flow is strongly dependent upon various parameters of the flow–radius ratio, angular velocity ratio, etc. Experimental torque measurements are obtained for a wide range of Reynolds numbers–from Stokes flow to boundary layer flow.

(*h*) **Viscous Incompressible Flow Between Eccentric Coaxially Rotating Spheres,** B. R. Munson, *Phys. Fluids* **17,** 3, pp. 528-531, 1974.
Experimental Results for Low Reynolds Number Flow Between Eccentric Rotating Spheres, M. Menguturk, B. R. Munson, *Phys. Fluids* **18,** 2, pp. 128-130, 1975.
Viscous Incompressible Flow Between Concentric Rotating Spheres. Part 3: Linear Stability and Experiment, B. R. Munson, M. Menguturk, *J. Fluid Mech.*, in press.
Flow in a Spherical Annulus, M. Menguturk, *Ph.D. Dissertation*, Dept. of Mech. Engr., Duke Univ., July 1974.
Experimental Investigation of Flow Between Rotating Spheres, A. M. Waked, *Ph.D. Dissertation*, Dept. of Engrg. Sci. and Mech., Jan. 1977.
Stability Characteristics of Eccentric Spherical Annulus Flow, *Developments in Theoretical and Applied Mechanics* **8,** *Proc. 8th SECTAM*, 1976.

064-09022-000-00

SELF EXCITED FLOW OSCILLATIONS

(*b*) Iowa State Univ. Engr. Research Institute.
(*c*) Dr. David K. Holger.
(*d*) Experimental and theoretical; basic research.
(*e*) Project is concerned with steady flow geometries in which the interaction between a free shear layer and solid boundary causes a periodic oscillation of the flow. Special applications of interest are pressure oscillations propagating into the surrounding fluid as sound and structural vibrations resulting from the flow solid boundary interaction.

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IOWA STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY, Department of Mechanical Engineering, Ames, Iowa 50011. Professor Arthur E. Bergles, Chairman.

065-10784-630-26

MULTISTAGE AXIAL-FLOW TURBOMACHINE WAKE PRODUCTION, TRANSPORT AND INTERACTION

(*b*) U.S. Air Force Office of Scientific Research, Iowa State University Engineering Research Institute.
(*c*) Theodore H. Okiishi, Professor.
(*d*) Experimental, applied research.
(*e*) An experimental study intended to lead to better understanding of the three-dimensional and unsteady aspects of multistage axial-flow turbomachine wake production, transport and interaction and to determining how this knowledge might be used to improve the aerodynamic acoustic and/or aeromechanical performance of such devices.
(*g*) Slow- and fast-response instrumentation has been employed to obtain time-average and periodic-average flow-field measurements between blade rows in a low-speed, multistage, axial-flow research compressor. Data indicate that rotor and stator blade exit flow patterns can vary significantly with the relative circumferential positioning of the stationary blade rows and with the sampling positions of rotor blades. Differences in aerodynamic and acoustic characteristics resulting from changes in unsteady wake interaction patterns have been observed.
(*h*) **Multistage Axial-Flow Turbomachine Wake Production, Transport and Interaction,** D. P. Schmidt, T. H. Okiishi, *AIAA Journal* **15,** pp. 1138-1145, 1977.

065-10785-050-54

PREDICTION OF BUOYANT TURBULENT JETS AND PLUMES

(*b*) National Science Foundation, Affiliate Research Program in Electrical Power.
(*c*) R. H. Pletcher, Professor.
(*d*) Theoretical, basic research.
(*e*) A finite-difference approach in a curvilinear, orthogonal coordinate system is being used for the analysis of turbulent, axisymmetric, buoyant jets and plumes issuing at arbitrary angles to a flowing ambient. The turbulent shear stress and heat transfer terms in the governing equations are evaluated through turbulent viscosity and conductivity models which contain parameters related to buoyancy and streamline curvature.
(*g*) Solutions have been obtained for the vertical buoyant jet discharging into a thermally stratified, quiescent ambient, the nonvertical buoyant jet discharging into a quiescent ambient, and the buoyant jet discharging at arbitrary angles into a cross-flow.
(*h*) **Prediction of Turbulent Jets in Coflowing and Quiescent Ambients,** I. K. Madni, R. H. Pletcher, *J. Fluids Engineering* **97,** pp. 558-567, 1975.
A Finite-Difference Analysis of Turbulent, Axisymmetric Buoyant Jets and Plumes, *Tech. Rept. HTL-10, ISU-ERI-Ames-76096*, Iowa State University, 1975.
Prediction of Turbulent Forced Plumes Issuing Vertically Into Stratified or Uniform Ambients, I. K. Madni, R. H. Pletcher, *J. Heat Transfer* **99,** pp. 99-104, 1977.
Buoyant Jets Discharging Nonvertically into a Uniform, Quiescent Ambient–A Finite-Difference Analysis and Turbulence Modeling, I. K. Madni, R. H. Pletcher, *J. Heat Transfer* **99,** Nov. 1977.
Prediction of Plumes from Power Plants, S. S. Hwang, R. H. Pletcher, *Annual Rept. ISU-ERI-Ames-77338*, *Affiliate Research Program in Electric Power*, Iowa State University, pp. 11.1-11.13, 1977.

065-10786-000-54

PREDICTION OF SEPARATED FLOWS

(*b*) National Science Foundation; Army Research Office.
(*c*) R. H. Pletcher, Professor.
(*d*) Theoretical, basic research.
(*e*) A finite-difference approach is being used for the prediction of incompressible laminar and turbulent separated flows, including regions of reversed flow and accounting for viscous-inviscid interactions.
(*g*) Studies indicate that current algebraic turbulence models perform poorly in the neighborhood of separation and in regions of recirculation. Predictions have been significantly improved by the use of a simplified transport equation for turbulence length scale.
(*h*) **A Direct Method of Calculating Through Separated Regions in Boundary Layer Flow,** R. H. Pletcher, C. L. Dancey, *J. Fluids Engineering* **97,** pp. 568-572, 1976.

065-10787-020-54

PREDICTION OF ANNULAR TURBULENT FLOWS

(*b*) National Science Foundation.
(*c*) R. H. Pletcher, Professor.
(*d*) Theoretical, basic research.
(*e*) Finite-difference methods are being used to solve the governing of partial differential equations of mass, momentum, and energy for the prediction of turbulent flow and heat transfer with property variations in straight annular passages.
(*g*) A turbulence model has been developed which utilizes a simplified transport equation for the characteristic mixing length scale in the central part of the flow. The model correctly predicts the center-line velocity overshoot in developing flow between parallel plates.

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IOWA, UNIVERSITY OF, Iowa Institute of Hydraulic Research **(see Iowa Institute of Hydraulic Research listing).**

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JET PROPULSION LABORATORY, see CALIFORNIA INSTITUTE OF TECHNOLOGY

LAMONT-DOHERTY GEOLOGICAL OBSERVATORY of Columbia University, Palisades, N. Y. 10964. Dr. Manik Talwani, Director.

066-08827-450-52

TRANSPORT AND TRANSFER RATE IN THE WATERS OF THE CONTINENTAL SHELF

(*b*) U.S. Energy Research and Development Administration.
(*c*) Dr. Pierre E. Biscaye, Senior Research Associate.
(*d*) Project incorporates experimental and theoretical aspects but it very importantly involves field investigations in the area of basic research.
(*e*) To obtain detailed, quantitative knowledge of the rates of mixing within coastal waters (including the Hudson Estuary) and across the continental slope, and the exchange of water masses and species transported within them between shelf waters and adjacent ocean water masses; and, by improved, quantitative knowledge of the chemical, physical and biological processes which control the origin, dispersal and fate of particulate matter, to understand and ultimately be able to model the impact of energy-related pollutants on the continental shelf.
(*f*) Active through September 1977.
(*h*) **Suspended Particulate Concentrations and Compositions in the New York Bight,** P. E. Biscaye, C. R. Olsen, *Middle Atlantic Continental Shelf and the New York Bight, Limnology and Oceanograpy, Special Symposia* **2**, pp. 124-137, 1976.
New York Bight Water Stratification–October 1974, A. L. Gordon, A. F. Amos, R. D. Gerard, *Middle Atlantic Continental Shelf and the New York Bight, Limnology and Oceanography, Special Symposia* **2**, pp. 45-57, 1976.

LAWRENCE BERKELEY LABORATORY OF THE UNIVERSITY OF CALIFORNIA, 1 Cyclotron Road, Berkeley, Calif. 94720. Geosciences Group, Group Leader: P. A. Witherspoon.

067-09983-820-52

HOT WATER STORAGE IN AQUIFERS

(*b*) U.S. Energy Research and Development Administration.
(*c*) Dr. Chin Fu Tsang.
(*d*) Theoretical; applied research.
(*e*) Detailed studies of the complex three-dimensional fluid and thermal flow patterns of a given aquifer system during injection of hot water and during retrieval later. The purpose of these studies is to evaluate the efficiency of energy storage and recovery, and to determine the feasibility of using aquifers as storage of hot water produced either as a by-product of electric power plants or from solar energy collectors.
(*g*) Surprisingly high storage-retrieval efficiencies are found. For seasonal storage with annual cycles, the percentage of energy recovered over energy stored is greater than 80 percent, and for daily storage, the figure is higher than 90 percent.
(*h*) **Numerical Modeling of Cyclic Storage of Hot Water in Aquifers,** C. F. Tsang, M. J. Lippmann, C. B. Goranson, P. A. Witherspoon. Presented *Symp. Cyclic Storage of Water in Aquifers*, AGU Fall Ann. Mtg., San Francisco, Dec. 6-10, 1977.
Modeling Underground Storage in Aquifers of Hot Water from Solar Power Systems, C. F. Tsang, C. B. Goranson, M. J. Lippmann, P. A. Witherspoon. Presented *Intl. Solar Energy Soc.* (*Amer. Sect.*) *Conf.*, Orlando, Fla., June 6-9, 1977.

LEHIGH UNIVERSITY, Department of Civil Engineering, Fritz Engineering Laboratory, Bethlehem, Pa. 18015. Dr. Robert L. Johnson, Director, Hydraulic and Environmental Engineering Division.

068-07403-370-60

DEVELOPMENT OF IMPROVED DRAINAGE INLETS

(*b*) Commonwealth of Pennsylvania, Department of Highways.
(*c*) Dr. Arthur W. Brune.
(*d*) Experimental; applied research.
(*e*) Highway drainage inlets currently in use are tested at a model: prototype ratio of 1:2 to determine the capacity of each for the conditions in which it is used. This information will be used to develop more efficient drainage inlets.
(*f*) Completed.
(*h*) **Hydraulic Performance of Pennsylvania Highway Drainage Inlets Installed in Grassed Channels,** E. Appel, *M.S. Thesis*, Lehigh University Library, 1972.
Hydraulic Performance of Pennsylvania Highway Drainage Inlets Installed in Paved Channels, A. W. Brune, P. P. Yee, W. H. Graf, *52nd Ann. Mtg. Highway Research Board*, Washington, D.C., 22 Jan. 1973.
Hydraulic Performance of Pennsylvania Highway Drainage Inlets Installed in Grassed Channels, E. Appel, A. W. Brune, W. H. Graf, *FLR 364.4*, 1973.
Hydraulic Performance of Highway Inlet Gratings, A. W. Brune, W. H. Graf, E. Appel, P. P. Yee, *ASCE Natl. Convention, Preprint 2390*, Kansas City, Mo., 21 Oct. 1974.
Performance of Pennsylvania Highway Drainage Inlets, A. W. Brune, W. H. Graf, E. Appel, P. P. Yee, *ASCE HY12, Paper 11801*, pp. 1519-1536, Dec. 1975.

068-10566-370-60

OPTIMAL DIMENSIONS FOR INLET GRATINGS

(*b*) Pennsylvania Department of Transportation.
(*c*) Dr. Arthur W. Brune.
(*d*) Experimental; design.
(*e*) Half-scale models of inlet gratings are tested for hydraulic efficiency with varying length-width ratios, the width being held constant.
(*h*) **Optimal Dimensions of Pennsylvania Highway Drainage Inlets in Paved Channels,** A. D. Spear, *M. S. Thesis*, Lehigh University Library, 1976.
Optimal Dimensions of Pennsylvania Highway Drainage Gratings Installed in Grassed Channels, A. D. Spear, A. W. Brune, *Fritz Engrg. Lab. Rept. No. 401.2*, 1976.
Optimal Dimensions of Pennsylvania Highway Drainage Gratings Installed in Paved Channels, A. D. Spear, A. W. Brune, *Fritz Engrg. Lab. Rept. No. 401.3*, 1976.

068-10567-810-88

STORM WATER MANAGEMENT

(*b*) Urban Observatory, Allentown, Pennsylvania.
(*c*) Dr. Robert L. Johnson.
(*d*) Field investigation; design and operation.
(*e*) Calibration and verification of computer model for predicting storm water quantity and quality. Development of design criteria for storm water retention basins and collection system evaluation.
(*h*) **Storm Water Management for Little Lehigh and Cedar Creek Drainage Basins,** R. L. Johnson, P. J. Usinowicz, R. D. Reardon, *Fritz Engrg. Lab. Rept. No. 416.2*, 1976.

068-10568-860-54

SEDIMENTATION IN RESERVOIRS

(*b*) National Science Foundation.
(*c*) Dr. W. A. Murray.
(*d*) Theoretical; applied research.
(*e*) Development of analytical and numerical methods to predict delta formation in reservoirs. Studies include investigation of sediment sorting, suspended and bed load contributions to reservoir sedimentation.

(*g*) Computer program for prediction of delta formation has been extended to include sediment sorting and real river-reservoir systems. An additional computer program has been developed to describe the gradually varied profile defining the interface between heavy turbid water of the underflow and the lighter sediment-free surface waters.
(*h*) **Numerical Investigation of Variable Density Underflow Currents,** J. J. Warwick, W. A. Murray, *Fritz Engrg. Lab. Rept. No. 410.2*, 1977.

068-10569-060-00

TURBIDITY PLUME FLOW IN UNIFORM AND STRATIFIED OCEAN WATER

(*c*) Dr. W. A. Murray.
(*d*) Theoretical; basic research.
(*e*) Physical and numerical modeling of steady discharge of fine-grain sediment slurry into ocean waters.
(*g*) Experimental results indicate that the flow of turbidity plumes is adequately described by equations of flow for simple, steady, fully turbulent plumes with a coefficient of entrainment, α, at 0.12 which is significantly greater than the value used for simple plumes without suspended solids.
(*h*) **Turbidity Plume Flow in Uniform and Stratified Ocean Water and Implications for Sediment Disposal,** C. R. Paola, W. A. Murray, *Fritz Engrg. Lab. Rept. No. 410.1*, 1976.

068-10570-220-54

ERODIBILITY OF SAND/CLAYEY SILT MIXTURES

(*b*) National Science Foundation.
(*c*) Dr. W. A. Murray.
(*d*) Experimental; applied research.
(*e*) Studies of the impact of varying fractions of clayey silt on the erodibility of coarse and/silt mixtures.
(*f*) Completed.
(*g*) Required bed shear stress to transport a given rate of sediment increased as the percent of fine material increased.
(*h*) **Erodibility of Coarse Sand/Clayey Silt Mixtures,** W. A. Murray, *Fritz Engrg. Lab. Rept. No. 411.2*, 1976.

LEHIGH UNIVERSITY, Department of Mechanical Engineering and Mechanics, Bethlehem, Pa. 18015. Professor J. A. Owczarek.

069-10460-480-54

USE OF SPLINES IN NUMERICAL WEATHER MODELING

(*b*) National Science Foundation.
(*c*) Dr. A. Macpherson.
(*f*) Completed.

069-10462-210-54

UNSTEADY TURBULENT FLOW IN TUBES

(*b*) National Science Foundation.
(*c*) Dr. F. T. Brown.

069-10463-650-73

FLUIDIZED BED COMBUSTION

(*b*) PSEF and PP and L.
(*c*) Drs. J. C. Chen and E. K. Levy.

069-10464-690-52

CENTRIFUGAL COMBUSTION OF COAL

(*b*) ERDA.
(*c*) Drs. E. K. Levy and J. C. Chen.

069-10465-480-73

SOLAR AND WIND ENERGY MEASUREMENTS

(*b*) PP and L.
(*c*) Drs. R. Sarubbi and D. Leenov.

LOS ALAMOS SCIENTIFIC LABORATORY of The University of California, Group T-3, P.O. Box 1663, Los Alamos, N. Mex. 87545. C. W. Hirt, Group Leader.

070-09014-640-54

WIND LOADS ON THREE-DIMENSIONAL STRUCTURES

(*b*) Energy Research and Development Administration.
(*c*) Leland R. Stein.
(*d*) Theoretical; applied research.
(*e*) Three-dimensional calculations are being performed on high-speed computers to verify that steady-state calculations of wind stresses agree with wind tunnel results. Also being examined are the pressure history on a structure when a unidirectional wind varies suddenly in speed and the effects of a wind that varies rapidly in directions, perhaps simultaneously changing its strength.
(*g*) Three-dimensional steady-state calculations of wind-produced stresses on simple structures agree well with wind tunnel data.
(*h*) **Prospects for Numerical Simulation of Bluff Body Aerodynamics,** C. W. Hirt, J. D. Ramshaw, *Proc. Symp. Aerodynamic Drag Mechanisms of Bluff Bodies and Road Vehicles*, General Motors Res. Lab., Warren, Mich., pp. 27-28, Sept. 1976.
Prospects for Studying Bluff Body Aerodynamics by High Speed Computer, C. W. Hirt, J. D. Ramshaw, L. R. Stein, *Computer Methods in Applied Mechanics and Engrg.* (submitted for publication).

070-09016-270-52

NUMERICAL STUDY OF PULSATILE FLOW IN ARTERIES

(*b*) Energy Research and Development Administration.
(*c*) Bart J. Daly.
(*d*) Theoretical; applied research, development.
(*e*) A numerical procedure is being developed for the purpose of studying the pulsatile flow of blood through distensible arteries, utilizing a computational method that permits virtually arbitrary and time-varying boundary configurations. The technique development has concentrated on the effective simulation of two crucial characteristics of blood flow in large arteries: a nonisotropic and space-varying elastic model of distensible arteries, and an efficient procedure for calculating pulsatile flow.
(*f*) Suspended.
(*g*) A study has been made of pulsatile flow through stenosed canine femoral arteries for lumen constrictions in the range 0-61 percent. Quantitative measurements of the pressure drop across the stenosis, the peak wall shear, and the development of local flow reversal in the wake of the stenosis are presented. Comparisons with *in vivo* measurements are made wherever possible. A second study examines changes in systolic flow development and blood pressure that result from the implantation of rigid prostheses of varying diameters in a canine thoracic aorta. The results of the study indicate that the greatest threat to graft survivability occurs when the prosthesis cross section is the same as the normal diastolic cross section. Optimum flow conditions exist when the prosthesis diameter is equal to the normal systolic diameter.
(*h*) **A Numerical Study of Pulsatile Flow Through Stenosed Canine Femoral Arteries,** B. J. Daly, *Biomechanics* **9**, pp. 465-475, 1976.
Pulsatile Flow Through a Tube Containing Rigid and Distensible Sections, B. J. Daly, *Proc. 5th Intl. Conf. Numerical Methods in Fluid Dynamics*, Twente Univ., The Netherlands, June 1976, Springer-Verlag.
A Numerical Study of the Effect of Prosthesis Size in Reconstructive Vascular Surgery, B. J. Daly, submitted for publication.

070-09260-740-20

NUMERICAL STUDY OF FREE SURFACE FLOWS PAST CURVED, RIGID BOUNDARIES

(*b*) Office of Naval Research, Fluid Dynamics Program.
(*c*) B. D. Nichols.

254-330 O - 78 - 6

(*d*) Theoretical; applied research; development.
(*e*) Numerical methods are being developed to calculate in two and three dimensions the transient dynamics of free surface flows past arbitrarily shaped bodies. These finite difference techniques are being used to numerically determine hydrodynamic forces on stationary, floating, and impacting cylinders. Particular attention is being given to nonlinear effects.
(*g*) The two-dimensional SOLA-SURF code was used to calculate the added mass and damping coefficients for rectangular and triangular cylinders in forced heave, sway, and roll motions. The numerical data for these calculations are in good agreement with linear theory. At large amplitudes, stronger secondary flow and other nonlinear effects become important. The three-dimensional SOLA-3D code was used to calculate the finite length effects associated with a triangular wedge in sway. It has been determined that the end effects are not significant for low amplitudes of motion for cylinder length to draft aspect ratios greater than two.
(*h*) **SOLA–A Numerical Solution Algorithm for Transient Fluid Flows,** C. W. Hirt, B. D. Nichols, N. C. Romero, *Los Alamos Scientific Lab. Rept. LA-5852 (1975) and LA-5852, Addendum (1976).*
Methods for Calculating Multi-Dimensional, Transient Free Surface Flows Past Bodies, B. D. Nichols, C. W. Hirt, *Proc. 1st Intl. Conf. Numerical Ship Hydrodynamics*, Gaithersburg, Md., 1975.
Numerical Calculation of Wave Forces on Structures, B. D. Nichols, C. W. Hirt, *Proc. 15th Intl. Conf. Coastal Engrg.*, Honolulu, Hawaii (1976).

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LOUISIANA STATE UNIVERSITY AND A&M COLLEGE, Agricultural Engineering Department, Baton Rouge, La. 70803. William H. Brown, Department Head.

071-05915-810-00

FACTORS AFFECTING RUNOFF ON SMALL AGRICULTURAL WATERSHEDS IN LOW, FLAT, ALLUVIAL AREAS

(*c*) Tom S. Chisholm, Asst. Professor.
(*d*) Field investigation; applied research; not specifically for thesis.
(*e*) Rainfall and runoff were measured on an event basis on a 50-acre pastured watershed graded to approximately 0.3 percent, located on the Mississippi River alluvial flood plain. The objective was to correlate runoff rates and volumes to rainfall rates and volumes.
(*f*) Terminated.
(*g*) Analysis was made of rainfall and runoff data from 43 storms which occurred during the period 1966 through 1969. Relationships were established between rainfall amount and runoff amount, and between rainfall amount and runoff peak rate. Comparisons were also made between the results from this watershed study and a similar study which was conducted on nearby cropland.
(*h*) **Raindrop Characteristics in South Central United States,** C. E. Carter, J. D. Greer, H. J. Braud, J. M. Floyd, *Trans. ASAE* **17**, 6, pp. 1033-1037, 1974.
Hydraulic Elements of a Partially Silted Round Section Flowing Partially Full, W. Talbot, H. J. Braud, *ASAE Paper No. 74-2507*, Dec. 1974.
Runoff from a Pastured Watershed in Louisiana, T. S. Chisholm. Manuscript approved for publication as a bulletin of the Louisiana Agricultural Experiment Station.

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LOUISIANA STATE UNIVERSITY AND A & M COLLEGE, School of Engineering, Baton Rouge, La. 70803.

072-08693-820-61

EFFECT OF VISCOSITY RATIO ON THE RECOVERY OF FRESH WATER STORED IN SALINE AQUIFERS

(*b*) La. Water Resources Research Institute.
(*c*) Dr. O. K. Kimbler, Professor, and W. R. Whitehead, Asst. Professor, Department Petroleum Engineering.
(*d*) Experimental, basic research, M.S. theses.
(*e*) The effect of viscosity difference on the extent of fluid mixing that occurs when an injected fluid miscibly displaces the native fluid was studied experimentally in two artificially consolidated sandstone miniaquifers of differing thicknesses. Fourteen experimental injection/storage/production runs were made with the injected fluid to native fluid viscosity ratio ranging from 0.25 to 4.
(*f*) Completed, June 1976.
(*g*) It was found that during an I/S/P run the amount of mixing which occurred could be described in terms of an "effective" dispersivity which was a function of viscosity ratio. The effective dispersivity can be used in existing computer programs (which are for viscosity ratios of one) to predict the recovery efficiency of an I/S/P run when the injected fluids have both differing viscosities and densities.
(*h*) Completion report in press, April 1977.
Effect of Viscosity Ratio on the Recovery of Fresh Water Stored in Saline Aquifers, B. K. Agrawal, *M.S. Thesis*, La. State Univ., Baton Rouge, La., Dec. 1975.

072-09926-890-61

EFFECT OF MIXED ZONE LENGTH ON THE GROWTH OF VISCOUS FINGERS DURING A MISCIBLE DISPLACEMENT

(*b*) Louisiana Water Resources Research Institute.
(*c*) W. R. Whitehead, Asst. Professor, and O. K. Kimbler, Professor, Department of Petroleum Engineering; R. G. Kazmann, Professor, Department of Civil Engineering.
(*d*) Theoretical and experimental.
(*e*) See WRRC 11, 4.0084.

072-09927-350-61

PHYSICAL AND ECONOMIC CONSEQUENCES OF FAILURE OF THE OLD RIVER CONTROL STRUCTURE

(*b*) Louisiana Water Resources Research Institute.
(*c*) Professor R. G. Kazmann, Asst. Professors E. B. Jernigan and R. D. Gilbert, Department of Civil Engineering; Professor D. B. Johnson, Department of Economics.
(*d*) Applied research.
(*e*) See WRRC 11, 8.0017.

072-09928-820-61

EVALUATION OF AQUIFER SYSTEMS AS PROCESSING PLANTS FOR THE MODIFICATION OF THE COMPOSITION OF INJECTED WATER

(*b*) Louisiana Water Resources Research Institute.
(*c*) Dr. J. S. Hanor, Professor, Department of Geology.
(*d*) Experimental, applied research, both M.S. and Ph.D.
(*e*) To quantify understanding of the mechanisms which control water composition in selected Gulf Coast aquifers. Research concentrated on identifying natural processes which control water composition in fresh-water aquifers in East Baton Rouge and West Baton Rouge Parishes (counties), Louisiana. A study was made of the evolution in water composition that has occurred over the last 40 years, and 60 additional well water samples were collected and analyzed. This work will have application in evaluating the modification of water composition caused by diffusion of dissolved species from aquicludes into injected bodies of fresher water. A series of experiments were run in which Mississippi River water was reacted in closed systems with various sedimentary materials.

(*g*) Calcium-rich fresh waters were introduced into sediment column containing sand, montmorillonite, and Na-rich saline waters. The Ca-rich waters were then pumped out of the columns and analyzed. It was found that ion-exchange with the montmorillonite significantly modified the composition of the waters. Calcium was preferentially removed from the injected waters by exchange with sodium initially adsorbed on the clays.

(*h*) **The Sedimentary Genesis of Hydrothermal Fluids,** J. S. Hanor, *The Geochemistry of Hydrothermal Fluids*, H. L. Barnes (ed.), (in press).

A Non-Steady-State Method for Determining Diffusion Coefficients in Porous Media, R. K. Stoessell, J. S. Hanor, *J. Geophys. Res.* **80,** pp. 4979-4982, 1975. Reprint No. 1-76 available from Director, La. Water Resour. Res. Inst., 146 Engrg. Drawing Bldg., La. State Univ., Baton Rouge, La. 70803.

072-09929-820-61

THE STORAGE OF FRESH WATER IN SALINE AQUIFERS–THE EFFECT OF AQUIFER DIP ON THE EFFICIENCY OF A MULTI-WELL SYSTEM

(*b*) Louisiana Water Resources Research Institute.

(*c*) R. G. Kazmann, Professor Department of Civil Engineering; O. K. Kimbler, Professor, and W. R. Whitehead, Asst. Professor, Department of Petroleum Engineering.

(*d*) Theoretical and experimental.

(*e*) When fresh water is injected into a salaquifer, due to density difference the fresh water tends to rise to the roof of the aquifer. In a dipping aquifer the fresh water not only tends to rise to the roof of the aquifer, but also tends to slide updip, away from the well field. This results, as experimentally demonstrated, in a marked decrease in recovery efficiency of the process which depends on density difference, dip angle, and duration of the cycle. Nineteen experimental runs were conducted in one of our miniaquifers to determine how dip angle, density difference, and static storage time would affect the recovery of an injected fluid.

(*f*) Completed, June 1976.

(*g*) For a density difference of 0.077 gm/cc, recovery efficiencies ranged from a high of 64.3 percent for a dip angle of 0 degrees and static storage time of 250 minutes to a low of 12.6 percent for a dip angle of 10 degrees and static storage time of 48 hours. From the results of the nineteen experimental runs it was concluded that the greater the density difference, dip angle, or static storage time, the lower the recovery efficiency.

(*h*) Completion report in preparation.

Cyclic Storage of Fresh Water in Saline Aquifers, O. K. Kimbler, R. G. Kazmann, W. R. Whitehead, *La. Water Resour. Res. Inst. Bull.* **10,** La. State Univ., Baton Rouge, La., Oct. 1975. Available from Director, La. Water Resour. Res. Inst., 146 Engrg. Drawing Bldg., La. State Univ., Baton Rouge, La. 70803.

Effect of Dip on the Storage of Fresh Water (or the Disposal of Waste), P. T. Tate, *M.S. Thesis*, La. State Univ., May 1976.

Effect of Dip on the Subsurface Storage or Disposal of Fluid in Saline Aquifers, J. A. D'Amico, *M.S. Thesis*, La. State Univ., Aug. 1975.

Effect of Viscosity Ratio on the Recovery of Fresh Water Stored in Saline Aquifers, B. K. Agrawal, *M.S. Thesis*, La. State Univ., Dec. 1975.

Use of Bounding Wells to Counteract the Effects of Pre-Existing Groundwater Movement, W. R. Whitehead, E. J. Langhetee, *Preprint H-46*, presented *AGU Fall Ann. Mtg.*, San Francisco, Dec. 6-10, 1976.

MARTIN MARIETTA CORPORATION, Martin Marietta Laboratories, 1450 South Rolling Road, Baltimore, Md. 21227. Dr. Albert C. Westwood, Director of MML.

073-08069-010-26

AERODYNAMICS-BOUNDARY LAYER

(*b*) Air Force Office of Scientific Research (in part).

(*c*) Dr. K. C. Wang.

(*d*) Theoretical; applied research.

(*e*) Development of numerical methods for exact calculations of three-dimensional laminar boundary layers and to examine thereby the nature of such viscous flows, and in particular to study laminar flow near separation.

(*g*) Calculation of three-dimensional laminar boundary layer has been extended to cases involving reversed flow. Ideas developed for three-dimensional steady case are found directly applicable to two-dimensional unsteady case. Separation patterns in general three-dimensional flow have been studied, including typical inclined bodies of revolution, finite wings at incidence and corners between intersecting bodies.

(*h*) **Aspects of "Multi-Time Initial-Value Problem" Originating from Boundary Layer Equations,** K. C. Wang, *Phys. of Fluids* **18,** 8, pp. 951-955, 1975.

Boundary Layer Over a Blunt Body at Low Incidence with Circumferential Reversed Flow, K. C. Wang, *J. Fluid Mech.* **72,** 1, pp. 49-75, 1975.

Laminar Boundary Layer Over a Spinning Blunt Body at Incidence, K. C. Wang, *Martin Marietta Lab. Rept. TR 76-14C*, 1976.

Concentrated Vortex on the Nose of an Inclined Body of Revolution, T. Hsieh, K. C. Wang, *AIAA J.* **14,** 5, pp. 698-700, 1976.

Separation of Three-Dimensional Flow, K. C. Wang, *Martin Marietta Lab. Rept. TR 76-54C*, 1976. (Also to appear in Proc. Viscous Flow Symp., Lockheed-Georgia Co., Marietta, Ga.).

073-08070-540-26

LIFTING AERODYNAMIC SYSTEMS

(*b*) Air Force Office of Scientific Research.

(*c*) Dr. P. F. Jordan.

(*d*) Theoretical; applied research.

(*e*) Review of the methods of steady and unsteady lifting surface analysis to obtain better engineering analytical methods.

(*g*) For steady flow, an exact lifting surface solution has been found. For unsteady flow, a new approach which yields highly accurate results with relative little effort has been proven and is being developed.

(*h*) **On Lifting Wings with Parabolic Tips,** P. F. Jordan, *ZAMM* **54,** pp. 463-477, Aug. 1974.

Numerical Evaluation of the 3-D Harmonic Kernel, P. F. Jordan, *Z. Flugwiss.* **244,** pp. 205-209, July/Aug. 1976.

Integration of the 3-D Harmonic Kernel, *AFOSR-TR-76-0948*, Aug. 1976.

073-08695-870-60

PLUME RISE AND DISPERSION MODELS FOR STACK EMISSIONS

(*b*) Maryland Department of Natural Resources.

(*c*) Dr. J. C. Weil.

(*d*) Theoretical and field investigation; applied research.

(*e*) Development of simple analytical models for predicting the rise and dispersion of heated stack emissions in flat and complex terrain and testing of the models with field data around large fossil-fueled power plants.

(*g*) The Gaussian plume model has been evaluated at three power plants in relatively flat terrain to determine the best method for estimating plume dispersion. Studies are planned to investigate meteorological perturbations caused by large rivers adjacent to two power plants and to examine the effect of these perturbations on plume dispersion. A modified Gaussian plume model to account for the effect of elevated terrain on plume transport is presently being evaluated with field measurements around a large sulfur dioxide source located in mountainous terrain.

(*h*) **Evaluation of the Gaussian Plume Model at the Dickerson Power Plant,** J. C. Weil, A. E. Jepson, *Atmospheric Environment* (in press).
Evaluation of the Gaussian Plume Model at Maryland Plants, J. C. Weil, Maryland Power Plant Siting Program, Dept. Natural Resources, *Ref. No. PPSP-MP-16* (Mar. 1977).

073-09998-630-52

WIND TURBINE ROTORS

(*b*) U.S. Energy Research and Development Administration (ERDA), Division of Solar Energy.
(*c*) Dr. P. F. Jordan.
(*d*) Theoretical; applied research.
(*e*) Develop the concept of aeroelastically self-adjusting rotor blades.
(*g*) The concept appears to be feasible and technically promising.
(*h*) **Segmented and Self-Adjusting Wind Turbine Rotors,** P. F. Jordan, R. L. Goldman, *ERDA Rept. COO-2613-2*, presented *12th Intersociety Energy Conversion Engrg. Conf.*, Washington, D.C., Aug. 28-Sept. 2, 1977.

UNIVERSITY OF MARYLAND, Institute for Physical Science and Technology, College Park, Md. 20742. Dr. J. Silverman, Director.

074-08072-130-50

TWO-PHASE FLOW OF A MIXTURE OF A FLUID AND SMALL SOLID PARTICLES

(*b*) National Aeronautics and Space Administration.
(*c*) Dr. S. I. Pai, Research Professor.
(*d*) Theoretical studies of two-phase flow.
(*e*) The fundamental equations of two-phase flow of a mixture of a gas and small solid particles are discussed from the two-fluid theory of continuum point of view. Some insights about the pseudo-fluid of solid particles were obtained. The fundamental equations were numerically solved for the case of lunar ash flow.
(*f*) Completed.
(*g*) Recently Professor S. I. Pai and Dr. Y. Hsu applied the two-phase flow theory to study the volcanic flows on the earth and on the moon. Under dynamically similar conditions, it was found that the exit velocity of lunar volcanic flow might be higher than the lunar escape velocity. This result confirms the hypothesis that Australian tektites came from the moon as a stream of a mixture of rock and gas at extremely high speed.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Department of Civil Engineering, Ralph M. Parsons Laboratory for Water Resources and Hydrodynamics, Cambridge, Mass. 02139. Donald R. Harleman, Laboratory Director.

Requests for reprints and reports should be addressed to Professor Donald R. F. Harleman, Laboratory Director, Room 48-311, M.I.T.

075-05544-440-00

THERMAL STRATIFICATION AND WATER QUALITY IN LAKES AND RESERVOIRS

(*b*) Ford Professorship.
(*c*) Professor D. R. F. Harleman.
(*d*) Experimental and analytical; basic research (Master's and Doctoral theses).
(*e*) Development of mathematical models for the prediction of the seasonal distribution of temperature and water quality parameters in lakes and reservoirs with horizontal stratification.
(*g*) A mathematical model has been developed which predicts the yearly cycle of temperature distribution within a reservoir and the outlet water temperature. The model accounts for heat input from inflowing streams, solar radiation, heat output from evaporation, radiation and at the reservoir outlet. The mathematical model was verified by comparison with temperature observations in a laboratory reservoir having artificial insolation and with field data for Fontana and Flaming Gorge Reservoirs. A water quality model has been coupled with the temperature distribution model to predict the distributions of conservative and nonconservative substances. Current work involves the incorporation of wind mixing in the prediction of the transient vertical temperature distribution. This avoids the specification of vertical diffusivities which have usually been used as "fitting" parameters.
(*h*) **Simulation of the Vertical Thermal Structure of Lakes under Transient Meteorological Conditions,** D. R. F. Harleman, K. A. Hurley, Workshop on *Dynamics of Stratification and Stratified Flow in Large Lakes*, Great Lakes Research Advisory Board, Windsor, Ontario, Feb. 1976.

075-06413-420-20

SURFACE WAVE STUDIES

(*b*) Office of Naval Research, Dept. of the Navy.
(*c*) Professor C. C. Mei.
(*d*) Theoretical (M.S. and Ph.D. theses).
(*e*) Harbor oscillations, floating bodies, waves and currents.
(*g*) Harbor resonance: Finite amplitude effects are studied in a rectangular bay of small depth. Theory and experiments are compared. Transient effects.
Near shore circulation due to breaking waves: Around islands and along beaches. Possible inferences on mass transport in waves and tides. Effect on sand deposit. Wave power extraction from floating booms.
(*h*) **Resonant Scattering by a Harbor with Two Coupled Basins,** C. C. Mei, U. Unluata, *J. Engrg. Mathematics*, Sept. 1976.
Longshore Circulation Around a Circular Conical Island, C. C. Mei, D. Angelides, *Intl. J. Coastal Engrg.*, Jan. 1977.
Power Extraction from Water Waves, C. C. Mei, *J. Ship Research* **20,** 2, pp. 63-66, 1976.
The Effect of Periodic Topography on Near Shore Circulation, C. C. Mei, *J. Estuary and Marine Sciences*, 1977.
Transient Response in Harbors, J. Risser, *M.S. Thesis*, 1976.
Effects of Topographical Variations on Mass Transport in Oscillatory Flows, J. Lamoure, *M.S. Thesis*, 1976.
Ship Waves in Canals of Continuously Varying Depth, M. Darras, *M.S. Thesis*, 1976.

075-08083-450-44

THE SEA ENVIRONMENT IN MASSACHUSETTS BAY AND ADJACENT WATERS

(*b*) Sea Grant Office, National Oceanic and Atmospheric Administration.
(*c*) Professors J. J. Connor and B. R. Pearce.
(*d*) Field studies and theoretical; basic and applied research (S.M. and Ph.D. theses).
(*e*) An interdisciplinary study with the objective of a comprehensive understanding of the physical environment of the waters of Massachusetts Bay and adjacent waters. Primary emphasis is on the definition and solution of pollutant transport problems. Initially, work was oriented toward methods and instruments for data acquisition and analysis and for the collection of baseline data throughout the Bay and at specific regions of man's intervention into the coastal zone. Increased surveillance of the Bay environment and development of mathematical models describing the physical environment of Massachusetts Bay are the present objectives.

(*g*) The special instrumentation developments have been completed. An extensive field program including physical and chemical parameter measurements is being conducted in support of modeling efforts for this project. Finite element models for circulation and dispersion in well-mixed shallow water masses have been developed and distributed. Work on the establishment of suitable numerical stability criteria is continuing. The formulation and computer implementation of two-layer models has been completed.

(*h*) **A User's Manual for "CAFE-1" a Two-Dimensional Finite Element Circulation Model,** Pagenkopf, Christodoulou, Pearce, Connor, *TR-217*, R. M. Parsons Lab., M.I.T., Sept. 1976.

A User's Manual for "DISPER-1" A Two-Dimensional Finite Element Dispersion Model, Pagenkopf, Christodoulou, Pearce, Connor, *TR-218*, R. M. Parsons Lab., M.I.T., Sept. 1976.

A User's Manual for "CAFE-2" a Two-Layer Finite Element Circulation Model, Pagenkopf, Christodoulou, Pearce, Connor, R. M. Parsons Lab., M.I.T., Oct. 1976.

A User's Manual for "DISPER-2" a Multi-Layer Finite Element Dispersion Model, Christodoulou, Pagenkopf, Pearce, Connor, R. M. Parsons Lab., M.I.T., Nov. 1976.

Mathematical Modeling of Dispersion in Stratified Waters, Christodoulou, Connor, Pearce, *TR-219*, R. M. Parsons Lab., M.I.T., Sept. 1976.

075-08084-820-36

ANALYSIS AND PREDICTION OF SUBSURFACE WATER QUALITY

(*c*) Professor J. L. Wilson.

(*d*) Theoretical and experimental; basic research (Master's and Doctoral theses).

(*e*) Several aspects of mass transport in porous media are being explored using mathematical models and laboratory experiments. The emphasis is on phenomena which are of importance in describing and forecasting groundwater quality. Mathematical methods of describing longitudinal dispersion in general nonuniform and unsteady flows are being studied. Also included are mixing phenomena in unsaturated flows and the convective and dispersive mixing process near pumping wells.

(*g*) Analytical solutions of the convective dispersion equation for uniform flow and certain nonuniform, unsteady flows have been obtained using singular perturbation techniques. Analytical solutions for mass transport in one-dimensional infiltration unsaturated flows have been applied to problems of practical interest. A conceptual mathematical "random tube" model of dispersion in unsaturated porous media has been developed. A user oriented hybrid 2D finite-difference/analytical model of mass transport in phreatic or confined aquifers has been developed. The model solves for the piegometric head distribution and flow field, then calculates tracer travel time along specified flow lines. Numerically integrating along the flow lines, the model determines the amount of dispersive mixing and calculates tracer concentration.

(*h*) **A Statistical Model of a Partially Saturated Porous Medium,** J. L. Wilson, L. W. Gelhar, presented *Symp. Solute Transport in Subsurface Water*, AGU Fall Mtg., 1975.

Solute Transport in the Unsaturated Zone, L. W. Gelhar, J. L. Wilson, presented *Symp. on Solute Transport in Subsurface Water*, AGU Fall Mtg., 1975.

075-08719-410-11

DYNAMICS OF COASTAL CURRENTS

(*b*) Coastal Engineering Research Center, U.S. Army Corps of Engineers.

(*c*) Professor C. C. Mei.

(*d*) Theoretical and experimental; basic research (Doctoral thesis).

(*e*) Mean currents induced by waves incident on a long straight beach interrupted by a long jetty or an offshore breakwater. Relation to sand transport by waves.

(*f*) Completed.

(*g*) To provide a semi-empirical theory of nearshore currents due to breaking waves in the presence of a shore-connected breakwater or an offshore breakwater. In particular, the effects of diffraction are studied in addition to refraction by shoaling waters. The concept of radiation stresses recently applied to uniform longshore current and rip currents forms the starting point of the theory. Ignoring inertia and lateral turbulent diffusion, the governing equations are solved numerically by the method of finite differences. Sample results for stream functions and mean sea levels are plotted for various beach profiles or incidence angles. For the offshore breakwater the predicted current pattern is consistent with available laboratory observations and the known tendency of tombolo formation. For the shore-connected breakwater, the computed flow pattern exhibits cells in both down-wave and up-wave regions. Directly relevant observations have not been found but part of the predicted features have indirect experimental support. More experimental and theoretical work is suggested.

(*h*) **Water Motion Near a Breakwater on a Beach; Waves, II: Mean Currents,** C. C. Mei, P. L. F. Liu, *J. Geophysical Research* **81**, 18, pp. 3078-3094, 1976.

075-08721-520-54

STUDIES OF SHIP HYDRODYNAMICS IN SHALLOW AND RESTRICTED WATER

(*b*) National Science Foundation.

(*c*) Professor C. C. Mei and Professor J. N. Newman (Ocean Engineering).

(*d*) Basic research (Master's and Doctoral theses).

(*e*) Behavior of ship motion in channels of variable depth or width. Ship to ship interactions in shallow water, effects on channel banks and nonlinear effects.

(*g*) In the first phase, efforts have been focused on an analytical-numerical study of two-dimensional surface waves generated by a steadily moving body. The bottom depth is finite and the body shape is arbitrary. A hybrid-element approach has been developed which discretizes into finite elements a limited region near the body. This approach is based on a variational principle which incorporates the matching conditions between regular and super-elements as natural boundary conditions.

A theory is developed for ships in shallow water moving at any speed (including the critical speed $U=\sqrt{gh}$). The equation is shown to have both nonlinearity and dispersion. Some analytical solutions have been worked out. Further numerical studies are underway to find the ship wave and the wave forces, especially near the critical speed where usual theories fail.

(*h*) **A Hybrid Element Method for Steady Two-Dimensional Free Surface Flows,** C. C. Mei, H. S. Chen, *J. Numerical Methods in Engrg.* **10**, 5, pp. 1153-1176 (1976).

Flow Around Thin Ships Moving in Shallow Water, C. C. Mei, to appear in *J. Fluid Mechanics*, 1977.

075-08723-410-75

SAND TRANSPORT BY WAVES

(*b*) Dames and Moore, Inc., and Public Service Elec. and Gas. Co. (New Jersey).

(*c*) Professor O. S. Madsen.

(*d*) Theoretical and experimental; basic and applied research (Doctoral thesis).

(*e*) Development of an analytical model for the sand transport associated with the combined action of waves and currents.

(*f*) Completed.

(*g*) Shields' criterion for the onset of motion in steady, uniform flow has been shown to apply also for the unsteady, oscillatory flow associated with wave motion. By reanalyzing experimental data for the average rate of sand transport under purely oscillatory flow conditions, an empirical expression for the rate of sediment transport associated with oscillatory flow has been developed. This analytical model of sediment transport in unsteady flow is used in conjunction with the sediment continuity equation to develop a general computer program predicting the rate of erosion and/or deposition due to a spatially varying wave and current field. As an example the program is applied to obtain the erosion and deposition patterns in the vicinity of a semi-infinite breakwater subject to incident waves and a current parallel to the breakwater.

(*h*) **Sediment Transport in the Coastal Environment,** O. S. Madsen, W. D. Grant, R. M. Parsons Lab., *Tech. Rept. No. 209*, M.I.T., Dec. 1975.
Sediment Transport in the Coastal Zone, W. D. Grant, O. S. Madsen, *Proc. 3rd Inter-Agency Sedimentation Conf.*, Denver, Colo., pp. 628-638, Mar. 1976.
Quantitative Description of Sediment Transport by Waves, O. S. Madsen, W. D. Grant, *Proc. 15th Coastal Engrg. Conf.*, Hawaii, July 1976.

075-08724-430-11

POROUS BREAKWATERS

(*b*) National Science Foundation (previously supported by U.S. Army Corps of Engineers, Coastal Engineering Research Center).
(*c*) Professor O. S. Madsen.
(*d*) Theoretical and experimental; applied research (Master's and Engineer's theses).
(*e*) Determination of the reflection and transmission characteristics of porous rubble-mound breakwaters.
(*g*) A simple yet accurate analytical approach to the determination of the reflection and transmission of relatively long waves normally incident on a porous rubble mound breakwater. An explicit analytical, totally predictive model for the reflection from and transmission through crib-style breakwaters has been developed. For trapezoidal breakwaters the energy dissipation taking place on the seaward slope is evaluated by a combined theoretical and experimental approach and is used in conjunction with the results for the reflection and transmission characteristics of a crib-style breakwater to predict the wave reflection from and transmission through trapezoidal, porous breakwaters. The present effort is aimed at obtaining an improved theoretical model for the interaction of an incident wave and the porous seaward slope of the breakwater, and will be followed by an experimental investigation.
(*h*) **Reflection and Transmission Characteristics of Porous Rubble-Mound Breakwaters,** O. S. Madsen, S. M. White, R. M. Parsons Lab., *Tech. Rept. No. 207*, Jan. 1976. (S.M. and C.E. Thesis of S. M. White)
Energy Dissipation on Rough Slopes, O. S. Madsen, S. M. White, *ASCE J. Waterways, Harbors and Costal Engrg.* **102**, WW1, pp. 31-48, Feb. 1976.
Reflection and Transmission Characteristics of Porous Rubble-Mound Breakwaters, O. S. Madsen, S. M. White, U.S. Army, Coastal Engrg. Res. Center, *Misc. Rept. No. 76-5*, Mar. 1976.

075-08727-870-73

THERMAL STUDIES–ATLANTIC GENERATING STATION

(*b*) Public Service Electric and Gas Company, N. J.
(*c*) Professors K. D. Stolzenbach and D. R. F. Harleman, and Dr. E. E. Adams.
(*d*) Theoretical and experimental (field studies) (Master's and Doctoral theses); basic and applied research.
(*e*) Pertinent features of the offshore site are a breakwater enclosure for the floating nuclear units, associated facilities for intake and discharge of condenser cooling water, and natural heat processes at the site. This includes predictions of the near and far field temperature distributions for alternative thermal discharge schemes and for a range of naturally occurring conditions in the receiving water.
(*g*) Experimental studies have been conducted to determine the interaction of the ocean bottom with heated surface and sub-surface discharges. Objective is to develop analytical or numerical techniques for prediction of the near and far-field temperature distribution in coastal waters. Results of measurements of ocean currents and temperature distribution and dye diffusion observations at the proposed site have been incorporated into a mathematical model of the far-field temperature distribution. Statistical characterization of receiving water states have been developed in conjunction with the application of this model.
(*h*) **The Stochastic Simulation of Ocean Currents,** D. V. Ingraham, *S.M. Thesis*, Dept. Civil Engrg., M.I.T., Jan. 1976.
Initial Temperature-Area Calculations for the Atlantic Generating Station, D. R. F. Harleman, E. E. Adams, D. V. Ingraham, S. Freudberg, K. D. Stolzenbach, *Progress Rept. No. 10*, to Public Service Electric and Gas Co., Oct. 1975.
Near and Far Field Excess Temperature and Velocity Calculations for the Atlantic Generating Station, E. E. Adams, S. A. Freudberg, K. D. Stolzenbach, D. R. F. Harleman, submitted to Public Service Electric and Gas Co., Oct. 1976.

075-08728-400-36

PREDICTIVE MODELS FOR UNSTEADY SALINITY AND TEMPERATURE DISTRIBUTION IN ESTUARIES

(*b*) Environmental Protection Agency and Environmental Devices Corporation.
(*c*) Professor D. R. F. Harleman.
(*d*) Theoretical; basic research (Master's and Doctoral theses).
(*e*) Development of a finite difference model to predict time-dependent longitudinal salinity and temperature distributions in an estuary or reservoir. The model couples the continuity and momentum equations for the tidal motion with the one-dimensional transport equations for salinity and temperature. The model incorporates the time-dependent boundary conditions of tidal range at the ocean end and variable fresh water inflows at the head of the estuary and from tributaries along the estuary.
(*f*) Completed.
(*g*) Recent applications include use of the model to predict ambient temperature distributions in Conowingo Reservoir under time varying meteorological conditions and unsteady flows due to the operation of hydroelectric reservoirs at the upstream and downstream boundaries. Comparisons with field data taken prior to the operation of Peachbottom Nuclear Power Station have been made. Model is being used for post-operational studies.
(*h*) **One-Dimensional Temperature Predictions in Unsteady Flows,** D. N. Brocard, D. R. F. Harleman, *Proc. ASCE* **102**, HY3, Mar. 1976.

075-08729-400-36

NUMERICAL MODEL FOR INTERACTING WATER QUALITY PARAMETERS IN ESTUARIES

(*b*) Environmental Protection Agency and Ford Professorship.
(*c*) Professors D. R. F. Harleman.
(*d*) Theoretical; basic research (Master's and Doctoral theses).
(*e*) An estuary consisting of channels and junctions is modeled mathematically by a network of one-dimensional channels. A finite element model is used for solution of the equations of motion and mass transfer with tidal advection and dispersion included for each branch of the network. These equations are solved, subject to interactions among branches and boundary conditions on the network as a whole, to provide time-dependent concentration distributions for non-conservative water quality parameters. Current research is on the development of a predictive model for interacting water quality parameters such as temperature, salinity, and nutrients under transient tidal, fresh water inflow and variable waste loading conditions.
(*g*) Seven components of the total nitrogen cycle have been included in the model due to their relevance to the study of eutrophic processes in estuarine environments. Of the inorganic forms of nitrogen the model includes NH_4^+-N, NO_2^--N and NO_3^--N. The organic forms of nitrogen are phytoplankton-N, zooplankton-N, particulate organic-N (PON) and dissolved organic-N (DON). Simulation runs have been made for the Potomac estuary and studies of the Willemette River (Oregon) are currently underway.

(*h*) **A Real-Time Model of Nitrogen-Cycle Dynamics in an Estuarine System,** T. O. Najarian, D. R. F. Harleman, *Proc. Conf. on Nitrogen as a Water Pollutant* **2,** Intl. Assoc. Water Pollution Research, Copenhagen, Aug. 1975.
Real Time Models for Salinity and Water Quality Analysis in Estuaries, D. R. F. Harleman, *Symp. on Estuaries, Geophysics and The Environment*, AAAS Mtg., Boston, Feb. 1976.
Model of Nitrogen Cycle in an Estuary, T. O. Najarian, D. R. F. Harleman, *ASCE Natl. Water Resources and Ocean Engrg. Convention*, San Diego, Apr. 1976.
User's Manual for the M.I.T. Transient Water Quality Network Model Including Nitrogen-Cycle Dynamics for Rivers and Estuaries, D. R. F. Harleman, J. E. Dailey, M. L. Thatcher, T. O. Najarian, D. N. Brocard, R. A. Ferrara, *Tech. Rept. 216*, R. M. Parsons Lab. Water Resources and Hydrodynamics, Dept. of Civil Engrg., M.I.T., Sept. 1976.

075-08732-870-52

EVALUATION OF WATER TEMPERATURE PREDICTION MODELS

(*b*) U.S. Nuclear Regulatory Commission and Laboratory Internal Funds.
(*c*) Professors D. R. F. Harleman and K. D. Stolzenbach; Drs. G. H. Jirka and E. E. Adams.
(*d*) Theoretical; basic and applied research.
(*e*) Study to assist the nuclear power plant licensing branch of ERDA in the assessment of environmental impacts of proposed plants. This will consist of a critical review of temperature prediction models, examining approximations, limitations, degree of field verification and utility. Emphasis is on the formulation of quantitative criteria for model applicability and on the development of a prediction methodology.
(*g*) The mathematical formulations of various mathematical models have been analysed. Models have been compared to available laboratory and field data in the following categories: surface discharges (near-field), far-field dispersion, cooling ponds. Also experimental techniques have been reviewed.
(*h*) **An Assessment of Techniques for Hydrothermal Prediction,** G. H. Jirka, G. Abraham, D. R. F. Harleman, Dept. Civil Engrg., M.I.T., Ralph M. Parsons Lab. Water Resources and Hydrodynamics, *Tech. Rept. No. 203*, July 1975; also published by the U.S. Nuclear Regulatory Comm., *Rept. NUREG-0044*, Mar. 1976 (Available NTIS, Springfield, Va. 22161).
Heat Disposal in the Water Environment, D. R. F. Harleman, G. H. Jirka, K. D. Stolzenbach, P. R. Ryan, E. E. Adams, M.I.T. Press, Cambridge, Mass., to be published Spring 1977.

075-08734-440-75

DYNAMICS OF SHALLOW COOLING PONDS

(*b*) Commonwealth Edison Company, Chicago, and NUS Corporation.
(*c*) Professor D. R. F. Harleman; Drs. G. H. Jirka and M. Watanabe.
(*d*) Experimental and theoretical; basic and applied research.
(*e*) Development of a predictive model for the cooling characteristics of shallow, artificially diked cooling ponds; analysis of specific ponds of this type within the CECO system; development of a user's manual; establishment of design criteria to control pond behavior and maximize cooling efficiency.
(*g*) Schematic laboratory experiments and analysis of field data have demonstrated the importance of the velocity field on the cooling efficiency. Both lateral circulations in the form of eddies and longitudinal dispersion have significant effects. Criteria have been developed which predict the degree of stratification in a pond as a function of site, shape, loading and mixing. Transient mathematical models have been developed for the lateral circulation and the dispersive effects and applied to the laboratory experiments and prototype tests. Design modifications on several existing ponds have been investigated.

075-08735-410-00

DIFFUSER INDUCED CIRCULATIONS IN SHALLOW COASTAL ZONES

(*b*) Waste Heat Management Research Program of the M.I.T. Energy Laboratory.
(*c*) Professor D. R. F. Harleman, Dr. G. H. Jirka.
(*d*) Theoretical and experimental; basic and applied research (Doctoral thesis).
(*e*) Submerged multiport diffusers for the disposal of waste heat from thermal-electric power generating facilities discharge a considerable amount of cooling water with substantial momentum. In shallow coastal waters these diffusers have the potential of inducing currents of considerable magnitude. An understanding of the induced current pattern is necessary to assess potential heat re-entrainment and the effect on coastal morphology. A theoretical investigation combined with a series of basic experiments is underway.
(*g*) The experimental investigation has been completed, different diffuser configurations have been tested with and without ambient currents and their near-field and far-field behavior has been analyzed. Preliminary criteria for the effect of model size on far-field circulations have been developed. A model which predicts the temperature distribution downstream from a unidirectional diffuser discharge has been developed including the following mechanisms: basic entrainment due to the diffuser momentum, side entrainment due to lateral shear and bottom friction.

075-08736-340-73

HEAT DISPOSAL FROM EMERGENCY CORE COOLING

(*b*) Offshore Power Systems.
(*c*) Professor D. R. F. Harleman and Dr. G. H. Jirka.
(*d*) Theoretical and experimental; basic and applied research (Master's thesis).
(*e*) Nuclear power plants release a transient heat load to the environment in case of normal and emergency shutdown procedures. The study is concerned with the external fluid mechanics of this heat disposal into a body of receiving water. The primary objective is an investigation of the cooling characteristics of offshore floating nuclear power plants which release the heat into a breakwater enclosure and are subject to regulatory specifications.
(*f*) Completed.
(*g*) A numerical stratified flow model for emergency heat releases has been developed. Major components of the model are: jet entrance mixing, stratified counterflow at breakwater openings, selective withdrawal at submerged intakes and surface heat dissipation. The model results have been verified in a concurrent schematic experimental study. The model demonstrates the importance of the design of the breakwater openings for the ultimate heat sink mechanism.
(*h*) **Theoretical and Experimental Investigation of Emergency Heat Releases from Floating Nuclear Power Plants,** G. H. Jirka, D. W. Wood, D. R. F. Harleman, *Tech. Rept. No. 206*, Dept. Civil Engrg., M.I.T., Ralph M. Parsons Lab. Water Resources and Hydrodynamics, Oct. 1975.
Transient Heat Releases from Offshore Nuclear Plants, G. H. Jirka, D. W. Wood, D. R. F. Harleman, *J. Hydraulics Division, ASCE*, Feb. 1977.

075-08738-340-54

POLICY OPTIONS IN REGIONAL POWER PLANT SITING: METHODOLOGY AND A NEW ENGLAND CASE STUDY

(*b*) National Science Foundation–Energy Traineeship.
(*c*) Professor D. H. Marks.
(*d*) Applied research.
(*e*) Methodology and quantitative models for examining the impact on a regional power expansion plan of fuel options (particularly coal) and environmental controls.
(*g*) Model development phase.

075-08741-820-88

TRAINING OF SPANISH ENGINEERS IN THE FIELD OF GROUNDWATER POLLUTION

(*b*) Food and Agriculture Organization of the United Nations.
(*c*) Professors J. L. Wilson, R. L. Lenton.
(*d*) Training program; applied research (Master's thesis).
(*e*) A training program for four Spanish engineers and an economist in the field of groundwater pollution was developed. The program was structured around formal subjects, special seminars, work-study trips, a case study, and a state-of-the-art review. Areas of interest included the causes, types and extent of pollution; methods of analysis: simulation, prediction and optimization; technology of groundwater pollution prevention, monitoring, detection and control; and methods and effects of pollution control: environmental, economic, legal and social.
(*f*) Completed.
(*g*) The Spanish team completed a case study of the water resources of the Valencia Plain of Spain and a review of the economics, management and technology of groundwater pollution. The review paper describes various aspects of groundwater pollution problems, and presents the application of some well-known concepts in pollution management and economics to groundwater.
(*h*) **Groundwater Pollution: Technology, Economics and Management,** J. L. Wilson, R. L. Lenton, J. Porras, *Tech. Rept. No. 208*, Dept. Civil Engrg., M.I.T., Ralph M. Parsons Lab. Water Resources and Hydrodynamics, 1976.

075-08749-800-54

BAYESIAN METHODOLOGY FOR WATER RESOURCES RESEARCH

(*b*) National Science Foundation.
(*c*) Professors I. Rodriguez and R. L. Lenton.
(*d*) Theoretical; applied research.
(*e*) Development of Bayesian methodologies for application in hydrologic analysis and water resources planning. The work focused on Bayesian regression analysis; Bayesian approach to multivariate Markov models; and model selection in hydrologic problems.
(*f*) Completed.
(*g*) During the first year, the work concentrated on the development of Bayesian multivariate Markov models for streamflow generation. A model was developed that explicitly accounted, in addition to the natural uncertainty in the hydrologic variables, for the uncertainty existing in the estimation of the parameters of the model due to the finite size of the historical sample. During the second year, three frequently asked questions about the use of regression models in hydrology were answered in a Bayesian framework. These were what the prediction-variables that are included in a regression model should be; what the structural form of the regression model should be; and what the form of the covariance matrix of the disturbances should be.
(*h*) **Linear Model Discrimination Theory Applied to the Choice of Structure and Form of Hydrologic Regression Models,** J. B. Valdes, I. Rodriguez-Iturbe, *Tech. Rept. No. 212*, Dept. Civil Engrg., M.I.T., Ralph M. Parsons Lab. Water Resources and Hydrodynamics, June 1976.
Discrimination of Alternative Hydrologic Regression Models: A User's Manual, J. B. Valdes, *Tech. Note No. 19*, Dept. Civil Engrg., M.I.T., Ralph M. Parsons Lab. Water Resources and Hydrodynamics, July 1976.
Bayesian Generation of Synthetic Streamflows: Part II: The Multivariate Case, J. B. Valdes, I. Rodriguez-Iturbe, G. J. Vicens, submitted for publication, *Water Resources Research*, 1976.
Bayesian Discrimination of Hydrologic Regression Models, J. B. Valdes, G. J. Vicens, I. Rodriguez-Iturbe, to be submitted to *Water Resources Research*, 1976.
A Bayesian Approach for the Use of Regional Information in Hydrology, G. J. Vicens, I. Rodriguez-Iturbe, J. C. Schaake, *Water Resources Research*, 1975.
Bayesian Generation of Synthetic Streamflows, G. J. Vicens, I. Rodriguez-Iturbe, J. S. Schaake, submitted for publication, *Water Resources Research*, 1975.

075-08750-810-44

A FRAMEWORK FOR LINKING THE ECONOMICS, PHYSICS AND STATISTICS IN THE DESIGN OF AN OPTIMAL RAINFALL DATA COLLECTION NETWORK

(*b*) National Weather Service, NOAA, U.S. Dept. of Commerce.
(*c*) Professor R. L. Bras.
(*d*) Theoretical; applied research.
(*e*) Network design schemes which allow consideration of spatial correlation of measured process (prior knowledge); physics describing the measuring system; errors involved in the measuring techniques; errors in the modeling of the area; and joint consideration of statistical and economic properties of the possible designs.
(*f*) Completed.
(*g*) A procedure in designing an optimal network to measure the total precipitation of an event once a fixed area has been given. The methodology allows the consideration of spatial correlation, errors of measurement and non-homogeneous sampling costs. A statistically non-stationary, multi-dimensional rainfall generator has been proposed. The model has been used together with a runoff model to study the accuracy of discharge prediction as a function of the rainfall sampling network.
(*h*) **Evaluation of Mean Square Error Involved in Approximating the Areal Average of a Rainfall Event by a Discrete Summation,** R. L. Bras, I. Rodriguez-Iturbe, *Water Resources Research* **12,** 2, Apr. 1976.
Rainfall Generation: A Nonstationary Time-Varying Multidimensional Model, R. L. Bras, I. Rodriguez-Iturbe, *Water Research* **12,** 3, June 1976.
Network Design for the Estimation of the Areal Mean of an Event, R. L. Bras, I. Rodriguez-Iturbe, *Water Resources Research*, 1976.
Rainfall Network Design for Runoff Prediction, R. L. Bras, I. Rodriguez-Iturbe, *Water Resources Research*, 1976.

075-08753-800-33

EXPLORATIONS IN MULTIOBJECTIVE WATER RESOURCE HISTORY

(*b*) Office of Water Resources Research.
(*c*) Professor D. C. Major.
(*d*) Applied research.
(*e*) Key selected American water resources projects and programs from 1900-1960 are analyzed from the standpoint of multiobjective theory.

075-08757-870-00

DESIGN OF ENVIRONMENTAL MONITORING PROGRAMS

(*b*) Waste Heat Management Group, M.I.T. Energy Laboratory.
(*c*) Dr. S. F. Moore and Professor S. W. Chisholm.
(*d*) Theoretical; applied research.
(*e*) Development of quantitative methodologies for the design and management of hydrothermal and biological monitoring programs for coastal waters subject to heated water and other waste discharges.
(*g*) Ecological monitoring is defined as an interative experimental design problem in which the overall working hypothesis is: heated water discharges from a coastal power plant do not effect the aquatic community into which they are released in a statistically and ecologically significant manner. Management of a monitoring program consists of cyclic process of experiment design; data collection and analysis; and program evaluation (objective specification and comparison of actual with desired results).

075-08760-870-44

MUTUAL INTERACTION BETWEEN PHYTOPLANKTON GROWTH AND TRACE METAL SPECIATION

(*b*) Sea Grant Office, National Oceanic and Atmospheric Administration.
(*c*) Professor F. M. M. Morel.
(*d*) Fundamental and applied research.
(*e*) In the fundamental part of this project, the interactions between trace metals (particularly copper) and various species of fresh water and marine phytoplankton are being studied systematically. Free copper ion concentration is presumed to be an important factor in inhibiting algal growth and limiting primary productivity. The role that organic ligands, either exuded by the cells or from external sources, play in controlling the biologically availability of trace metals is being explored. This interdisciplinary project is carried on jointly with the Chemistry Department.
(*g*) Chelating properties of released cellular organics have been characterized by potentiometric titrations. A major effort to isolate and characterize these chelators by high pressure liquid chromotography is now underway. Comparison of the copper sensitivity of various phytoplankters and the protective role of iron with respect to copper toxicity have been investigated.

075-08765-880-54

DEVELOPMENT OF LEGAL AND REGULATORY FRAMEWORK FOR MINING OF HARD MINERAL RESOURCES IN THE COASTAL ZONE

(*b*) National Science Foundation.
(*c*) Professor M. S. Baram.
(*d*) Applied research leading to development of policy and regulatory program recommendations.
(*e*) Review and assessment of information on mineral resources in the coastal zone, feasible technologies for extraction, potential impacts and externalities, monitoring capabilities, legal and regulatory authorities and their decision-processes. Analysis and development of appropriate legal and regulatory framework for conduct of coastal mining.
(*f*) Completed.
(*h*) Final report in progress.

075-08767-340-00

ARTIFICIAL ISLANDS FOR OFFSHORE ENERGY FACILITIES

(*b*) Brookhaven–ERDA.
(*c*) Professor M. S. Baram.
(*d*) Applied research.
(*e*) Review of available information on artificial islands–concepts and developments to-date. Evaluation of economic feasibility, elements of which include siting of islands; construction of islands; operations of multiple energy facilities thereon; and associated activities. Assessment of adequacy of state and federal policies and regulatory programs.
(*f*) Completed.
(*h*) **Economic Feasibility of the Cluster Concept for Artificial Islands** and **Legal Considerations,** two-volume final report, M. S. Baram, (published by Brookhaven National Laboratory, 1976).

075-09795-420-44

NUMERICAL THEORY OF WATER WAVES

(*b*) Sea Grant Office, NOAA.
(*c*) Professor C. C. Mei.
(*d*) Fundamental and applied (Master's theses).
(*e*) Wave forces and scattering effects for large offshore structures.
(*f*) Completed.
(*g*) Based on a hybrid approach, the method of finite elements is used to solve linearized three-dimensional wave problems numerically. Convergence and accuracy are tested and computer codes are written in a manual. Potentially useful for many ocean structural problems.
(*h*) **A Hybrid Element Method for Three Dimensional Water Waves,** D. K. P. Yue, H. S. Chen, C. C. Mei, *Proc. 11th Symp. on Naval Hydrodynamics*, London, Apr. 1976.
A Hybrid Element for Calculating Three-Dimensional Water Wave Scattering, D. K. P. Yue, H. S. Chen, C. C. Mei, *Tech. Rept. No. 215*, R. M. Parsons Lab. Water Resources and Hydrodynamics, Dept. Civil Engrg., M.I.T., 1976.

075-09796-420-44

OCEAN WAVE ENERGY SYSTEMS

(*b*) Sea Grant Office, NOAA.
(*c*) Professors C. C. Mei and A. D. Carmichael (Ocean Engrg. Dept.).
(*d*) Theoretical, experimental and applied.
(*e*) Hydrodynamics, design and engineering evaluation of a floating device for wave power.
(*g*) This is a joint project with the Department of Ocean Engineering. At Parsons Laboratory attention is focused on the hydrodynamic aspects, optimal body shape, wave forces, etc.

075-09797-410-44

LONGSHORE SEDIMENT TRANSPORT

(*b*) Sea Grant Office, NOAA.
(*c*) Professor O. S. Madsen.
(*d*) Theoretical; basic and applied research (Master's and Doctoral theses).
(*e*) Development of an analytical model capable of predicting the rate and distribution of longshore sediment transport.
(*g*) Louguet-Higgins' solution for the wave induced longshore current on an infinite, plane beach is adopted in a slightly modified form. The sediment transport resulting from the combined action of this longshore current and the incident waves is estimated by adopting the sediment transport relationship described in the "Sand Transport by Waves" project. Calculated net rates of longshore sediment transport are compared with field and laboratory measurements to assess the accuracy of the theoretical model.
(*h*) **An Analytic Model for Longshore Sediment Transport,** A. S. Reyman, *S.M. Thesis*, Civil Engrg., Sept. 1976.

075-09798-420-44

VELOCITY DISTRIBUTION OF CURRENTS IN THE PRESENCE OF WAVES

(*b*) NOAA, AOML/Miami.
(*c*) Professor O. S. Madsen.
(*d*) Theoretical and experimental, basic research (Doctoral and Master's theses).
(*e*) Development of an analytical model for the vertical velocity distribution of a steady current in the presence of waters.
(*g*) The combined action of waves and currents is of extreme importance to the problem of sediment transport in the coastal environment. At present very little information is available on the bottom shear-stress associated with the combined action of an unsteady oscillatory flow (waves) and a steady current. Only for a pure wave motion, or for a pure current is it possible to estimate the magnitude of the bottom shear stress as a function of flow characteristics and bottom roughness. For waves and currents the flow resistance experienced by the steady current is found to be a function of the physical roughness of the boundary and the wave characteristics. A general computer program capable of evaluating the effective boundary roughness experienced by the current, and therefore the velocity distribution of current, in the presence of waves has been developed. Possibility of comparing the model with field measurements planned by NOAA/AOML exists.

075-09799-870-73

CIRCULATION AND DISPERSION STUDIES AT THE PILGRIM NUCLEAR POWER STATION, ROCKY POINT, MASSACHUSETTS

(*b*) Boston Edison Company.
(*c*) Professor B. R. Pearce.
(*d*) Theoretical (Master's thesis).
(*e*) Mathematical modeling of near and far field convective and dispersive processes in coastal areas. Supplemented by field measurements of physical parameters.
(*g*) Calculation of the dispersion of winter flounder from Duxbury Bay into Cape Cod Bay. Assessment of the increased cooling water throughout the proposed addition to the Pilgrim Nuclear Power Station and its affect on the resident flounder population in Duxbury Bay.
(*h*) **Circulation and Dispersion Studies at the Pilgrim Nuclear Power Station,** J. R. Pagenkopf, G. Christodoulou, B. R. Pearce, J. J. Connor, *Tech. Rept. 210*, R. M. Parsons Lab. Water Resources and Hydrodynamics, Dept. Civil Engrg., M.I.T., Feb. 1976.

075-09800-450-44

THREE-DIMENSIONAL CURRENT MODELING

(*b*) National Weather Service.
(*c*) Professor Bryan Pearce.
(*d*) Basic and applied research.
(*e*) Development of a weighted residual scheme to calculate the 3-D structure of currents in coastal areas using a depth varying eddy-viscosity. Project will include comparisons to current meter data in order to estimate the eddy-viscosity variation in the vertical.

075-09801-870-75

SOMERSET HYDROTHERMAL MODEL STUDY

(*b*) United Engineers and Constructors, Inc. (for New York State Electric and Gas Company).
(*c*) Professor K. D. Stolzenbach.
(*d*) Applied research (Master's thesis).
(*e*) A physical model study was conducted to determine the performance of proposed condenser water discharge configurations for the Somerset Power Plant which is sited on the south shore of Lake Ontario. An analytical study of the far field temperature distribution is being conducted to supplement the near field temperature distribution obtained by the physical model.
(*f*) Completed.
(*g*) The model study results indicated agreement with semi-empirical formulations for discharge behavior. The far field calculations indicate that induced far field temperatures will be relatively small and intermittent at any point.
(*h*) **Analytical and Experimental Studies of Discharge Designs for the Caguya Station at the Somerset Alternate Site,** K. D. Stolzenbach, C. W. Almquist, E. E. Adams, S. A. Freudberg, *Tech. Rept. No. 211*, Dept. Civil Engrg., M.I.T., Ralph M. Parsons Lab. Water Resources and Hydrodynamics, May 1976.
Staged Diffusers in Shallow Water, C. W. Almquist, K. D. Stolzenbach, *Tech. Rept. No. 213*, Dept. Civil Engrg., M.I.T., Ralph M. Parsons Lab. Water Resources and Hydrodynamics, June 1976.

075-09802-870-80

MEASUREMENT, ANALYSIS AND REGULATION OF ENVIRONMENTAL IMPACTS RESULTING FROM HEATED DISCHARGES FROM NUCLEAR POWER PLANTS

(*b*) Shell Oil Companies Foundation (through the M.I.T. Energy Laboratory).
(*c*) Professor K. D. Stolzenbach.
(*d*) Case study review and analysis (Master's thesis).
(*e*) A review of existing literature and technical analyses is being performed for the purpose of documenting the relationship between the measurement, analysis, and regulatory functions involved in licensing nuclear power plants. Attention is being focused on the licensing of open cycle condenser water systems. The purpose is to develop recommendations regarding possible improvements in the existing framework for interdisciplinary evaluation and regulation of environmental impacts.
(*f*) Completed.
(*g*) The review resulted in a documentation of present state water quality standards relating to water temperature; a summary of Federal discharge permits issued; a categorization of the types of engineering and biological studies performed in support of these efforts. A final report is in preparation.

075-09803-720-44

UNDERWAY BOAT SAMPLING OF HEATED DISCHARGES IN COASTAL WATERS

(*b*) Engineering Development Laboratory, National Ocean Survey, NOAA.
(*c*) Professors K. D. Stolzenbach and D. R. F. Harleman; Dr. E. Eric Adams.
(*d*) Theoretical; applied research.
(*e*) Study involves the deliniation of requirements for a high speed underway boat survey system for application to the analysis of heated discharges.
(*f*) Completed.
(*g*) A scenario was developed that used the heated discharge from the Atlantic Generating Station as a case study for the application of an underway boat system. The tasks defined for the boat system were (1) sampling of dye concentrations to determine diffusion coefficients and (2) monitoring of far field temperatures.
(*h*) **Use of an Underway Water Sampling System for the Analysis and Monitoring of the Heated Discharge from the Atlantic Generating Station,** K. D. Stolzenbach, E. E. Adams, S. A. Freudberg, D. R. F. Harleman, R. M. Parsons Lab. Water Resources and Hydrodynamics, M.I.T., Aug. 1976.

075-09804-870-44

REVIEW OF OIL SPILL TRAJECTORY MODELS

(*b*) Deepwater Ports Office, Environmental Data Service, NOAA.
(*c*) Professors K. D. Stolzenbach, O. S. Madsen, B. R. Pearce, J. J. Connor; Dr. E. Eric Adams.
(*d*) Theoretical basic and applied research (Master's theses).
(*e*) Purpose of the first phase of the study was to review and evaluate currently available techniques for modeling oil spill behavior, making recommendations for future data collection and basic research needs. A second phase will perform sensitivity analysis to further quantify the relative importance of the various processes affecting oil spill behavior.
(*g*) A workshop was held among invited experts in this field to discuss and evaluate the project draft report. The final report on the current phase of the project is in preparation.
(*h*) **A Realistic Model of the Wind-Induced Ekman Layer,** O. S. Madsen, *J. Physical Oceanography* 2, 1977.

075-09805-350-75

HYDRAULIC MODEL STUDY OF THE TENSAS-COCODRIE PUMPING PLANT FOREBAY

(*b*) Burk and Associates, Inc. and the U.S. Army Corps of Engineers.
(*c*) Professors J. L. Wilson and K. D. Stolzenbach.
(*d*) Experimental.
(*e*) A hydraulic model of the proposed Tensas-Cocodrie Pumping Plant Forebay was designed, constructed and operated. The objective of the study was to identify and correct features of the proposed forebay that are objectionable from a hydraulic standpoint.
(*f*) Completed.
(*g*) The model was tested for the original design configuration. The test results indicated the need to redesign the channel transition leading to the forebay because of large scale vortex formation in the transition area. In addition, changes in the geometry of the pump bays were made to prevent the formation of vortices at the pump bells.

(*h*) **Vortex Visualization in Hydraulic Models,** C. A. Gowan, *S.M. Thesis*, Dept. of Civil Engrg., M.I.T., May 1976.

075-09806-350-75

MEROM STATION HYDRAULIC MODEL STUDY

(*b*) United Engineers and Constructors, Inc.
(*c*) Professor K. D. Stolzenbach.
(*d*) Applied research (Master's thesis).
(*e*) A physical model study is being conducted to determine the performance of proposed inlet and discharge structures associated with the Merom Station cooling lake dam. Alternative designs will be investigated to correct any problems indicated by the model study.
(*g*) The model is presently under construction.

075-09807-870-75

TRANSIENT ANALYSIS OF DEEP COOLING LAKES WITH SIDE ARM CONVECTION

(*b*) Stone and Webster Engineering Corporation and Virginia Electric Power Company.
(*c*) Professor D. R. F. Harleman; Drs. G. H. Jirka and M. Watanabe.
(*d*) Experimental and theoretical; basic and applied research (Master's and Doctoral theses).
(*e*) Basic study of the buoyancy driven vertical circulation of cooling water into long shallow side arms of cooling ponds; development of a transient cooling pond model for heat distribution in shallow cooling ponds with lateral and vertical restrictions; development of a two-layered finite element model for solution of the mass heat and momentum conservation equations. Specific application of this investigation is the North Anna Cooling Lake in Virginia. Long-term predictions of cooling pond behavior under natural and various thermal loading conditions are being made.
(*g*) An experimental schematic study of the side arm circulation has been conducted, investigating different boundary conditions at the side arm entrance, bottom slopes and lateral constrictions. An analytical model of the side arm circulation has been developed.
A segmented transient cooling pond model has been formulated for the North Anna Cooling Lake taking account of the distinct geometric features.
A two-layered finite element model for the heat and velocity distributions in the upper layer of a cooling pond has been developed and verified with laboratory data.
Long-term meteorological data has been obtained through multiple correlation with several meteorological stations and subsequent synthetic data generation. Predictions for long-term pond performance have been given.
The existing M.I.T. Deep Reservoir Model has been modified to include the vertical heat transport processes which are generated by the wind shear effect at the water surface.
(*h*) **Buoyancy-Driven Circulations in Side Arms of Cooling Ponds,** D. N. Brocard, G. H. Jirka, D. R. F. Harleman, *Preprint No. 2628*, *ASCE Ann. Convention*, Denver, Colo., Nov. 1975.
Mathematical Modeling of a Stratified Cooling Pond, M. Watanabe, J. J. Connor, *Applied Mathematical Modeling* 1, 2, Sept. 1976.

075-09808-870-54

DYNAMIC ANALYSIS OF NUTRIENT REMOVAL BY WASTE STABILIZATION PONDS

(*b*) Ford Professorship and National Science Foundation.
(*c*) Professor D. R. F. Harleman.
(*d*) Theoretical and experimental; basic research (Master's and Doctoral theses).
(*e*) Develop a method for prediction of the dynamic behavior of waste stabilization ponds under transient conditions. A mathematical model has been formulated for use in the design of new ponds as well as for the analysis and improvement of existing facilities. The model will apply the "element cycle" method to track the transformation of nutrients into their various organic and inorganic forms.
(*g*) Initial investigations indicate that the application of the carbon cycle more completely simulates pond characteristics than the traditional B.O.D. approach. Analysis of data on laboratory model and field stabilization ponds is underway.

075-09809-430-52

OCEAN THERMAL ENERGY CONVERSION

(*b*) U.S. Energy Research and Development Administration (ERDA).
(*c*) Dr. G. H. Jirka and Professor D. R. F. Harleman.
(*d*) Theoretical and experimental; basic and applied research.
(*e*) Ocean thermal energy conversion (OTEC) plants have been proposed as a method of generating electrical power using the thermal energy difference between the warm upper layer and the cold lower layer which exists in the tropical oceans due to insolation. OTEC plants represent the only solar energy option for electrical base load power. They have a low thermal efficiency and thus require large water flows. An experimental and theoretical study is aimed at the determination of the external fluid dynamics of OTEC plants, i.e. mixing and withdrawal effects in the thermally stratified ocean, with the purpose of ascertaining whether these plants can fully utilize the available energy potential or whether local recirculations take place which would reduce the plant efficiency.
(*g*) A schematic experiment has been constructed in a shallow laboratory basin, simulating the mixing and dispersion processes in the upper layer of the ocean. Data from the experiments are being used in a concurrent mathematical zone modeling study at M.I.T. and for numerical modeling at the Naval Research Laboratory.

075-09810-870-52

WASTE HEAT MANAGEMENT IN THE ELECTRIC POWER INDUSTRY: ISSUES OF ENERGY CONSERVATIONS AND STATION OPERATION UNDER ENVIRONMENTAL CONSTRAINTS

(*b*) U.S. Energy Research and Development Administration (ERDA).
(*c*) Professor D. R. F. Harleman, Drs. E. E. Adams and B. Andeen (Mechanical Engineering); Dr. L. Glicksman (Mechanical Engineering); Dr. G. H. Jirka, Professor F. C. Schweppe (Electrical Engineering); Professor K. D. Stolzenbach and Dr. M. Watanabe.
(*d*) Theoretical research and assessments; applied research.
(*e*) Assessment of environmental impacts and energy conservation in waste heat management: Evaluation of the long-term and short-term tradeoff issues which arise from the choice of different cooling systems. Evaluation of regional effects; meteorological and hydrological transients; degree of internal design refinement in the plant-cooling system combination; effects of backfitting requirements and other environmental regulatory aspects. Investigation of long-term simulation methodologies of transient cooling system behavior.
Development of control technologies for supplementary cooling systems: Investigation of real-time control strategies which can be used to switch between different cooling modes such as to maximize system efficiency while meeting environmental constraints. Case study of the Browns Ferry Nuclear Power Plant as a typical river site offering alternative once-through cooling and cooling tower modes. Development of a probabilistic river temperature model and control algorithm; evaluation of monitoring requirements, regulatory constraints, tower performance characteristics and switching rules.

075-09811-820-00

PARAMETER ESTIMATION OF GROUNDWATER SYSTEMS

(*b*) M.I.T. Sloan Research Fund.

(*c*) Professors J. L. Wilson and R. L. Lenton.
(*d*) Theoretical; basic and applied research (Master's thesis).
(*e*) Assessment of existing parameter estimation methods for groundwater flow models. First order sensitivity analysis of estimators. Development of state-space forms of the model and explicit solutions convenient for parameter estimation, sensivity analysis, groundwater management applications, etc.
(*g*) A comprehensive review of the state-of-the-art revealed a lack of unification and unsatisfactory performance of applied methods. A new and unified approach in a Bayesian framework has been developed and applied. The results obtained indicate that since in most real-world cases the estimation of parameters must take place from effectively small samples, and in some cases from non-uniform data, it is necessary to use prior information about the parameters, combined in an optimal way with information obtained from the data.
(*h*) **A Unified Approach to the Parameter Estimation of Groundwater Models,** P. Kitanidis, *S.M. Thesis*, Dept. Civil Engrg., M.I.T., Feb. 1976.

075-09812-820-36

WASTE DISPOSAL FACILITIES SITING: GROUNDWATER POLLUTION EFFECTS

(*b*) Environmental Protection Agency Traineeship.
(*c*) Professors J. L. Wilson and D. H. Marks.
(*d*) Applied research (Doctoral thesis).
(*e*) Site selection and environmental impact assessment are two related components of the process in which large public facilities are proposed and eventually constructed. Research focused on the groundwater pollution impact of waste disposal facilities will examine the issues involved in choosing a site and how these are translated into social decision. Simple methods for estimating order of magnitude impacts on groundwater quality will be examined.

075-09813-870-54

ENVIRONMENTAL EFFECTS OF WESTERN STRIP MINING

(*b*) National Science Foundation Energy Traineeships.
(*c*) Professors J. L. Wilson and D. H. Marks.
(*d*) Applied research (Master's and Doctoral theses).
(*e*) A number of important issues relating to the impact of western strip mining on groundwater resources will be evaluated. These include the effects of aquifer destruction on available water supply, base flow reduction, aquifer renovation, water chemical quality, and alternative water supplies and water uses.

075-09814-070-54

DISPERSIVE MIXING OF NEGATIVELY BUOYANT PLUMES IN POROUS MEDIA

(*b*) National Science Foundation.
(*c*) Professor J. L. Wilson.
(*d*) Theoretical and experimental; basic and applied research (Master's thesis).
(*e*) Theoretical and experimental investigation of plumes of denser water which sink as they travel downstream, and which result from the introduction of liquids of a higher density into ambient aquifer flows. The analysis will incorporate the effects of density difference between ambient and aquifer flows, and will account for the effects of hydrodynamic dispersion on the mixing.

075-09815-800-33

SCREENING MODELS FOR REGIONAL PLAN FORMULATION

(*b*) Office of Water Resources Research–Rockefeller Foundation.
(*c*) Professors D. H. Marks, D. C. Major and S. A. West.
(*d*) Theoretical and applied research.
(*e*) Investigations to show the role of analytic models in the regional planning process. Emphasis is on water and related land use planning such as the ongoing project in the 4,400 square mile South East New England Study by the New England River Basin Commission. Objectives of the study are: 1) single resource supply models, such as water supply, water quality management, power plant siting; 2) land use–water resource impacts modeling; 3) resource allocation models; and 4) evaluation–indices for quality of life, eliciting preferences for alternative development plans.

075-09816-800-75

INTEGRATED RIVER BASIN DEVELOPMENT ON THE VARDAR/AXIOS, YUGOSLAVIA AND GREECE

(*b*) Tippetts Abbott McCarthy and Stratton (through UNDP).
(*c*) Professors D. H. Marks, R. L. Lenton and J. L. Wilson.
(*d*) Theoretical; applied research.
(*e*) The Vardar-Axios is a river system that starts in Yugoslavia and flows through Greece to the Aegean Sea. There are numerous plans for development in both countries for power, agricultural, water supply and flood control. The purpose of the M.I.T. project is to provide the modeling component for a study that will eventually lead to a draft compact between the two countries for integrated water resource planning and management.

075-09817-800-87

CAPACITY EXPANSION IN URBANIZING AREAS OF COLOMBIA

(*b*) USAID, Universidad de los Andes, Bogata.
(*c*) Professor D. H. Marks.
(*d*) Theoretical; applied research.
(*e*) Planning methodologies for capacity expansion under uncertainty, demand forecasting and decentralized planning will be explored. A Colombian counterpart group will help in applications and user orientation.

075-09819-810-54

HYDROLOGIC ESTIMATION FROM GEOMORPHOLOGY

(*b*) National Science Foundation.
(*c*) Professor Peter S. Eagleson.
(*d*) Theoretical, basic research.
(*e*) In the size, shape and topology of the stream channel network, the landform carries the distinctive signature of the integrated effects of geologically recent fluvial processes. This project seeks to establish relationships between these features and the current climatic and hydrologic regimes with a view toward their use in reducing the uncertainty of hydrologic estimation in the absence of hydrologic data.

075-09820-810-00

THE DISTRIBUTION OF ANNUAL WATER YIELD

(*b*) M.I.T. Sloan Basic Research Fund.
(*c*) Professor P. S. Eagleson.
(*d*) Theoretical; basic research.
(*e*) Probability densities are derived for the separate components (precipitation, infiltration evapotranspiration) of the one-dimensional annual water cycle from the probability densities of the individual storm and interstorm periods using the physics of the processes.
(*g*) The water balance is expressed in terms of a set of physically-derived dimensionless parameters which incorporate the coupling of climate and soil dynamics and which provide a rational means for hydrologic classification of regions. The theoretical recurrence interval of annual water yield is given in terms of physical parameters of the climate-soil system.
(*h*) **The Annual Water Balance–Its Statistical-Dynamics and Dynamic Similarity,** P. S. Eagleson, *Tech. Rept.* R. M. Parsons Lab., M.I.T., 1976 (in preparation).

075-09821-810-00

SHORT TERM RAINFALL PREDICTION FOR THE REAL TIME CONTROL OF URBAN DRAINAGE SYSTEMS

(*c*) Professors R. L. Bras and D. H. Marks.

(*d*) Theoretical; applied research.
(*e*) Real-time decisions for the operation of flood control systems in urban areas depend upon knowledge of the current state and a prediction of future inputs. Due to the relatively fast response of an urban drainage system prediction of future flows requires a short-term prediction of rainfall. This work will develop a methodology to continuously update and forecast estimates of rain-fall using data from a telemetered network.

075-09822-300-44

ON-LINE RIVER DISCHARGE FORECASTING USING FILTERING AND ESTIMATION THEORY

(*b*) National Weather Service, NOAA, U.S. Department of Commerce.
(*c*) Professor R. L. Bras.
(*d*) Theoretical; applied research.
(*e*) An on-line procedure of estimation and forecast is being developed using the Kalman Filter as the analytical tool to process real time information of rainfall and runoff.

075-09823-800-00

M.I.T.-ARGENTINA PROJECT: TEACHING MATERIALS

(*c*) Professors D. C. Major and R. L. Lenton.
(*d*) Curriculum development.
(*e*) Reports from the M.I.T.-Argentina project describe the application of modern investment criteria and mathematical modeling techniques to the development of plans for the Rio Colorado, Argentina. These reports are being edited to produce teaching materials.

075-09824-870-44

THE ROLE OF COPPER IN NEW ENGLAND RED TIDES

(*b*) Sea Grant Office–NOAA, International Copper Research Association and Doherty Professorship.
(*c*) Professor F. M. M. Morel.
(*d*) Fundamental and applied research.
(*e*) The role of trace metal chelation, particularly that of copper in controlling and triggering blooms of the dinoflagellate Gonyaulax tamarensis is being investigated systematically.
(*g*) Concentrations of Cupric ion that are toxic to the red tide organism have been determined in laboratory batch cultures. Encystment and excystment processes in function of the free copper ion activity have been studied in laboratory and natural populations.
(*h*) **Copper Induced Encystment in Gonyaulax Tamarensis,** D. M. Anderson, *S.M. Thesis*, Dept. Civil Engrg., M.I.T., 1976.

075-09825-870-36

CHEMICAL MODELING OF METALLIC WASTE DISPOSAL

(*b*) Environmental Protection Agency.
(*c*) Professor M. M. Morel.
(*d*) Applied research.
(*e*) The ultimate goal is to develop a predictive model for the fate and impact of trace metal pollutants in natural waters.
(*g*) A compact and more efficient computer program for chemical equilibrium calculations has been designed and implemented. A laboratory project is currently underway to test the validity of the predictions of the thermodynamic calculations for complex aqueous systems. The main focus is on the adsorption of trace metals by amorphous iron oxides. A new adsorption model has been developed and implemented as a subroutine for that purpose. Determination of the fundamental parameters is being performed experimentally.
(*h*) **A General Algorithm for the Computation of Chemical Equilibrium in Aqueous Systems,** J. C. Westall, J. L. Zachary, F. M. M. Morel, presented *Amer. Chemical Soc. Cent. Mtg.*, San Francisco, Calif., Aug. 1976.

075-09826-870-54

NUTRIENT UPTAKE AND GROWTH OF PHYTOPLANKTON UNDER UNSTEADY CONDITIONS

(*b*) NSF and Doherty Professorship.
(*c*) Professors S. W. Chisholm and F. M. M. Morel.
(*d*) Experimental and theoretical; basic research.
(*e*) Experimental examination of the characteristics of nutrient uptake and growth in nutrient limited phytoplankton cultures under transient conditions. A simulation model will be developed to attempt to satisfactorily describe (with three state variables) the dynamics of nutrient uptake and growth of a phytoplankter limited by one nutrient.
(*g*) Initial efforts have focused on a theoretical treatment of three models for the steady state growth of phytoplankton limited by one nutrient. Mathematical analysis of the three models (often presented as alternative models in current literature) proves them equivalent, which forces the conclusion that each model is an equally valid–or equally invalid– statement of algal growth at steady state. Future experimental and theoretical research will be designed to examine the validity of these models under conditions of unsteady phytoplankton growth. It is anticipated that the models will not be equivalent under unsteady conditions, and that a new model will have to be developed to satisfactorally describe the system under both steady state and transient conditions.
(*h*) **The Continuous Culture of Phytoplankton; Mathematical Equivalence Among Three Steady State Models,** D. E. Burmaster, submitted *J. Marine Research*, 1976.
Modeling Algal Growth Dynamics in Steady State Systems, J. P. Chaplik, *S.M. Thesis*, Dept. Civil Engrg., M.I.T., 1976.

075-09827-870-00

PHASED CELL DIVISION IN MARINE PHYTOPLANKTON: CHARACTERISTICS, MECHANISMS, AND SIGNIFICANCE

(*c*) Professor S. W. Chisholm.
(*d*) Basic research; experimental.
(*e*) Identify and describe those aspects of phytoplankton growth and physiology that are influenced by daily light/dark cycles. The specific characteristics and control mechanisms of the timing of cell division in individual species will be examined as well as the potential ecological significance of the phenomenon. Inherent in these objectives is the evaluation of the possible impact that the inclusion of rhythmic processes could have on current models dealing with phytoplankton growth.
(*g*) The timing of cell division in at least seven species of marine diatoms is phased (i.e., occurs over a restricted time interval when cells are grown in a 24-hour light/dark cycle) and is species-specific. Strong indirect and direct evidence suggests that phased cell division in diatoms and dinoflagellates occurs *in situ*, and that individual species may divide at different times of day. Several hypotheses concerning the phasing mechanism and the adaptive significance of the phenomenon are being considered and tested.
(*h*) **Silicic Acid Incorporation in Marine Diatoms in Light/Dark Cycles: Use as an Assay for Phased Cell Division,** S. W. Chisholm, F. Azam, R. W. Eppley, submitted *Limnology and Oceanography*.
Phased Cell Division in Natural Populations of Marine Dinoflagellates from Shipboard Cultures, C. S. Wieler, S. W. Chisholm, *J. Exp. Mar. Biol. Ecol.*, in press.

075-09828-870-73

SHORT-TERM FORECASTING OF SALEM HARBOR WATER TEMPERATURE

(*b*) New England Power Company.
(*c*) Dr. S. F. Moore.
(*d*) Applied research.
(*e*) Development of system for predicting discharge water temperatures from Salem Harbor Power Plant on a 24-

hour basis with 1 °F, 90 percent of the time. The system combines a model of temperatures in Salem Harbor with on-line temperature measurements and meteorologic forecasts using estimation theory. The purpose is to reduce frequency of unscheduled outlays presently incurred by exceeding discharge temperature standards.

(*f*) Completed.

(*g*) A working model and estimation scheme is developed. Additional work remains to identify model parameters and structure which yields results consistent with the ± 1 °F, 90 percent time criteria.

(*h*) **Hydrothermal Modeling for Optimum Temperature Control: An Estimation-Theoretic Approach,** B. P. Schrader, S. F. Moore, *Tech. Rept. No. 214*, Dept. Civil Engrg., M.I.T., Ralph M. Parsons Lab. Water Resources and Hydrodynamics, July 1976.

Once-Through Cooling at Salem Harbor Generating Station: Short-Term Temperature Forecasting and Policy Aspects of a Temperature Standard, B. P. Schrader, *S.M. Thesis*, Dept. Civil Engrg., M.I.T., 1976.

075-09829-860-88

DESIGN OF WATER QUALITY MONITORING SYSTEMS FOR RIVERS

(*b*) CSIRO Fellowship.

(*c*) Dr. S. F. Moore,

(*d*) Theoretical and applied research.

(*e*) Design of cost-effective water quality monitoring systems for rivers using estimation theory techniques. Abatement and prevention objectives are included. Account is taken or sources of uncertainty due to boundary conditions, inputs and uncertain parameters.

(*f*) Completed.

(*h*) **Design of Water Quality Sampling Systems for River Networks,** G. C. Dandy, *Ph.D. Thesis*, Dept. Civil Engrg., M.I.T., 1976.

075-09830-880-00

ENVIRONMENTAL LAW: SPECIAL PROBLEMS

(*b*) M.I.T.

(*c*) Professor M. S. Baram.

(*d*) Applied research.

(*e*) On legal and regulatory processes, and the analytical methods (e.g., cost-benefit analysis, assessments, etc.) used by decision-makers in setting standards, issuing permits and evaluating agency regulations and judicial decisions.

(*h*) **Analysis of Regulation and Decision-Making on Radioactive Emissions from Nuclear Power Plants** and **Legal and Ethical Issues in the Use of Cost-Benefit Analysis for Regulatory Decision-Making,** M. S. Baram, two chapters of *Rept. of Natl. Acad. Sciences Committee on Biological Effects of Ionizing Radiation* (Fall 1976).

Legal Aspects of EPA Manpower Decision Making, M. S. Baram, a chapter in *Natl. Acad. Sciences Rept. on EPA* (Winter 1976).

Environmental Law and the Siting of Facilities: Issues in Land Use and Coastal Zone Management, M. S. Baram, *Ballinger Press*, Apr. 1976.

UNIVERSITY OF MASSACHUSETTS, School of Engineering, Amherst, Mass. 01002. Dr. Russel C. Jones, Dean.

076-0431W-860-00

DEVELOPMENT OF A PROCEDURE FOR FIELD MEASUREMENT OF RIVER REAERATION RATES

See Water Resources Research Catalog **11**, 5.1357.

076-0432W-870-00

COST EFFECTIVE STREAM AND EFFLUENT MONITORING

See Water Resources Research Catalog **11**, 7.007.

076-06666-430-20

UTILIZATION OF MOBILE BREAKWATER DEVICES TO REDUCE SURFACE MOTIONS OF SUBMERSIBLE VEHICLES FOR DEEP OCEAN ENGINEERING PURPOSES

(*b*) Office of Naval Research.

(*c*) Dr. Charles E. Carver, Jr., Dept. of Civil Engineering.

(*d*) Experimental; applied research.

(*e*) The attenuation characteristics of a pneumatic and hydraulic breakwater used singly as well as in tandem have been investigated in the UMass Fluid Mechanics Laboratory Wind-Generated Wave Facility. Deep water wave spectra upstream and downstream of the breakwaters are measured as well as the power input to both breakwaters. The reduction in mean wave height is used as a measure of wave attenuation. The wind speed is held constant and discharge rates of air and water to the breakwaters are varied. Both devices are submerged to a depth of two feet. The surface current velocities due to the air and water jet action are measured with a midget current meter.

(*f*) Completed.

(*h*) **Attenuation of Wind-Generated Deep Water Waves by Vertical Jet Breakwaters,** J. M. LaCouture, J. M. Colonell, C. E. Carver, Jr., Univ. of Mass. School of Engrg., *Rept. No. UM-72-6*, June 1972.

Attenuation of Wind-Generated Waves by Pneumatic and Hydraulic Breakwaters, J. M. Colonell, J. M. Lacouture, C. E. Carver, Jr., *Proc. Conf. on Floating Breakwaters*, Newport, R.I., pp. 131-158, Apr. 23-25, 1974.

076-06682-540-14

A STUDY OF AIRBORNE TOWED VEHICLE DYNAMICS

(*b*) U.S. Army Research Office, Durham.

(*c*) Drs. C. R. Poli, D. E. Cromack, Dept. of Mechanical and Aerospace Engineering.

(*d*) Basic and applied; theoretical and experimental; Masters and Ph.D. theses.

(*e*) Stability of slung loads.

(*f*) Completed.

(*h*) **Dynamics of Slung Bodies Using a Single-Point Suspension System,** C. Poli, D. Cromack, *J. Aircraft* **10,** 2, Feb. 1973, pp. 80-86.

Dynamics of Slung Bodies Utilizing a Rotating Wheel for Stability, E. Micale, C. Poli, *J. Aircraft* **10,** 12, Dec. 1973, pp. 760-763.

Dynamics of Slung Loads, L. Feaster, C. Poli, R. Kirchoff, *J. Aricraft* **14,** 2, pp. 115-121, Feb.1977.

076-08773-620-70

STUDY OF COATING (LUBRICATION) FLOWS

(*b*) Kendall Corp., P. J. Schweitzer Company, Eastman Kodak.

(*c*) Dr. Stanley Middleman, Dept. of Chem. Engineering.

(*d*) Experimental and theoretical, basic and applied, Ph.D. and M.S. theses.

(*e*) Theoretical and experimental studies of lubrication type flows, with special application to the dynamics of coating of thin liquid layers onto moving surfaces, is underway. Of particular interest is the role of viscoelasticity in these flows, and the development of appropriate theoretical analyses for viscoelastic fluids.

(*g*) To date an analytical method based on perturbation theory has been carried out, which indicates the direction of viscoelastic effects.

(*h*) **Blade Coating of a Viscoelastic Fluid,** Y. Greener, S. Middleman, *Polymer Engrg. and Sci.* **14,** pp. 791-796, 1974.

076-08774-120-00

MODELING OF POLYMER FLOW PROCESSES

(*c*) Dr. Stanley Middleman, Dept. of Chem. Engineering.

(*d*) Experimental and theoretical; basic and applied; M.S. and Ph.D. theses.

(*e*) Computational methods are being developed for analysis of flows of complex (non-Newtonian viscoelastic) fluids in complicated flow fields. Experiments are performed in support of the theoretical work.

(*h*) **Laminar Mixing of a Pair of Fluids in a Rectangular Cavity,** D. Bigg, S. Middleman, *I and EC Fund.* **13**, pp. 66-71, 1974.
Mixing in a Screw Extruder. A Model for Residence Time Distribution and Strain, *I and EC Fund.* **13**, pp. 66-71, 1974.

076-08776-120-54

GROWTH AND COLLAPSE OF BUBBLES IN VISCOELASTIC FLUIDS

(*b*) National Science Foundation.
(*c*) Dr. Stanley Middleman, Dept. of Chem. Engineering.
(*d*) Experimental and theoretical; basic research, Ph.D.
(*e*) The dynamics and kinematics of bubble growth or collapse are being studied as a means of measuring the elongational viscosity of viscoelastic fluids.
(*g*) Elongational viscosity in polymeric solutions is observed to decrease with increasing strain rate.
(*h*) **Comments on a New Method for Determination of Surface Tension of Viscous Liquids,** G. Pearson, S. Middleman, *Chem. Engrg. Sci.* **29**, pp. 1051-1053, 1974.

076-10466-630-00

EXPERIMENTAL INVESTIGATION OF THE USE OF A SAVONIUS ROTOR AS A POWER GENERATING DEVICE

(*c*) Dr. Charles E. Carver, Jr.
(*d*) Experimental.
(*e*) Torque, power output and efficiency characteristics are determined for a Savonius rotor 3 feet high and 1.5 feet in diameter tested in a wind tunnel at speeds ranging from 15.6 to 21 feet per second.
(*f*) Completed.
(*g*) Maximum efficiency was found to be 33 percent occurring at a ratio of wind speed to rotor tip speed of about 0.88.
(*h*) **Experimental Investigation of the Use of a Savonius Rotor as a Power Generating Device,** C. E. Carver, Jr., R. B. MacPherson, *Proc. Symp. Wind Energy: Achievements and Potential*, University of Sherbrooke, pp. 137-156, May 29, 1974.

076-10467-030-70

VIRTUAL MASS OF A CYLINDER IMMERSED IN WATER

(*b*) Combustion Engineering Inc., Windsor, Conn. 06095.
(*c*) Dr. Gabriel Horvay.
(*d*) Theoretical, basic and applied research.
(*h*) **Beam Modes of Vibration of a Thin Cylindrical Shell Flexibly Supported and Immersed in Water Inside of a Coaxial Cylindrical Container of Slightly Larger Radius,** G. Horvay, *Nuclear Engrg. and Design* **26**, p. 291, 1974.
Influence of Entrained Water Mass on the Vibration Modes of a Shell, G. Horvay, *J. Fluids Engrg.* **97**, p. 211, 1975.
Forced Vibrations of a Shell Inside a Narrow Water Annulus, G. Horvay, *Nuclear Engrg. and Design* **34**, p. 221, 1975.

076-10468-000-70

LOW REYNOLDS NUMBER ENTRANCE FLOWS

(*b*) Kenics Corporation, North Andover, Mass.
(*c*) Dr. Robert L. Laurence.
(*d*) Experimental and theoretical; basic and applied, Ph.D. thesis.
(*e*) Theoretical and experimental studies of the flow field developed in a stationary mixing device with spatially periodic elements are underway. The goal is to understand the mixing function.
(*g*) A mathematical model has been developed and solved, yielding excellent pressure drop predictions. Residence time distributions have been used to check velocity field predictions with modest success.
(*h*) **A Coordinate Frame for Helical Flows,** T. T. Tung, R. L. Laurence, *Polymer Engrg. and Science* **15**, p. 401, 1975.

076-10469-000-00

STABILITY OF PERIODIC FLOWS

(*c*) Dr. Robert L. Laurence.
(*d*) Theoretical, basic, Ph.D. thesis.
(*e*) Stability of modulated circular couette flow to disturbances of arbitrary magnitude was studied.
(*g*) Modulation is destabilizing and it enlarges the region open to subcritical instability.
(*h*) **Linear Stability of Modulated Circular Couette Flow,** P. J. Riley, R. L. Laurence, *J. Fluid Mechanics* **75**, p. 625, 1976.
Energy Stability of Modulated Circular Couette Flow, P. J. Riley, R. L. Laurence, *J. Fluid Mechanics* **79**, p. 535, 1977.

076-10470-870-60

NON POINT POLLUTION FROM URBAN RUNOFF

(*b*) Massachusetts Division of Water Pollution Control.
(*c*) Dr. Donald Dean Adrian.
(*d*) Experimental; applied research.
(*e*) Loading factors for the U.S. Environmental Protective Agency's Storm Water Management Model (SWMM) are being measured for various land uses in Greenfield and Northampton, Mass. Both stormwater quantity and quality are monitored. The SWMM has been calibrated and verified for the study areas.
(*g*) An improved calibration and verification procedure for the quantity and quality portions of SWMM has been developed.
(*h*) **Methodology for Predicting Urban Stormwater Pollutant Loadings,** T. K. Jewell, T. J. Nunno, D. D. Adrian, presented *1977 Amer. Geophysical Union Mtg.*, Washington, D.C., 25 pages, May 30-June 3, 1977. Available from the authors.

076-10471-870-60

NON POINT POLLUTION FROM SANITARY LANDFILL LEACHATE

(*b*) Massachusetts Division of Water Pollution Control.
(*c*) Dr. Donald Dean Adrian.
(*d*) Field investigation; applied research.
(*e*) The production of metal and organic-laden leachate from a sanitary landfill at Barre, Mass. is being monitored. Production rates are being related to hydrologic factors.
(*g*) Leachate flowrates ceased during the winter freeze. The flowrate responds quickly to spring thaw and rainfall.
(*h*) **Specific Conductance as a Measure of Treatability of Landfill Leachate,** P. Walker, D. D. Adrian, *Proc. 32nd Ann. Purdue Industrial Wastes Conf.*, 15 pages, May 10-12, 1977, in press.

076-10472-860-36

SLUDGE THICKENING AND DEWATERING RATES

(*b*) U.S. Environmental Protection Agency.
(*c*) Dr. Donald Dean Adrian.
(*d*) Theoretical and experimental; applied research.
(*e*) The research is to develop and verify a new model of sludge thickening and dewatering. The model involves visualizing the thickening process as flow through a deforming porous medium, rather than as a sedimentation process.
(*g*) The proposed theoretical model fits experimental results very well and makes it easier to predict the effect of temperature change on flowrates.
(*h*) **Transport Phenomena Applied to Sludge Dewatering,** P. Kos, D. D. Adrian, *J. Env. Engrg. Div., ASCE* **101**, EE6, pp. 947-965, Dec. 1975.
Gravity Thickening of Water Treatment Plant Sludges, *J. Amer. Water Works Assn.* **69**, 5, pp. 272-282, May 1977.
Fundamental Principles and Mechanisms of Gravity Sludge Thickening, P. Kos, D. D. Adrian, *Boston Soc. of Civil Engrs. Sect. of ASCE, T. R. Camp Lecture Series on Wastewater Treatment and Disposal*, pp. 94-129.

MECHANICAL TECHNOLOGY INCORPORATED, Research and Development Division, 968 Albany-Shaker Road, Latham, N.Y. 12110. C. Boyajian, General Manager, Research and Development Division.

077-10574-130-52

PARTICLE SEPARATION FROM GAS STREAM BY CENTRIFUGING

(*b*) ERDA–Division of Fossil Energy Research.
(*c*) J. T. McCabe, Project Manager.
(*d*) A theoretical study to determine the feasibility of particle separation from a gas by a concept called a Cyclocentrifuge.
(*e*) Determine the effectiveness and economic advantage of employing centrifuges for gas particulate clean-up in processes relating to coal conversion and utilization. A theoretical aerodynamic analysis was made covering the blading characteristics required to impart the necessary swirl to the air to separate out dust particles in a reasonable path length, achieving zero exit swirl velocity.
(*f*) Phase I–Feasibility Study completed. Phase II–Model Testing and demonstration not yet started.
(*g*) Gas cleanup was determined to be an area in which the special characteristics of modified centrifuge offered technical and economic advantages over existing approaches. A new concept, called a Cyclocentrifuge, was evolved during the study which combined the best gas cleanup features of cyclones and centrifuges in a compact design capable of separating fine particulate matter from hot gas at large flow rates. A design example showed the Cyclocentrifuge to be capable of achieving a purity of 1 ppm of solids with a nominal maximum particle diameter of one micron when processing low Btu fuel from a coal gasifier.
(*h*) *MTI Tech. Rept. MTI 77R34*, available Tech. Info. Center, Special Asst. for Reproduction and Processing, U.S. ERDA, P.O. Box 62, Oak Ridge, Tenn. 37830.

077-10575-630-20

RESEARCH PROGRAM ON HELIUM FLOW IN CLOSED CYCLE GAS TURBINES

(*b*) Office of Naval Research.
(*c*) Thomas J. Ivsan, Project Engineer.
(*d*) An experimental program to determine the factors affecting the performance of axial flow compressor stages using helium gas as contrasted to air. The study includes the performance of suitable helium gas lubricated bearings.
(*e*) Project is concerned with two facets of component development for a closed-cycle gas turbine powerplant. One task is to experimentally evaluate a high-reaction axial compressor using helium gas to determine the effects of gas characteristics different from air. The second task is to analytically and experimentally evaluate support of the rotor on bearings lubricated by the helium.
(*f*) Analysis and test facility preparation in progress.
(*g*) The project will evaluate helium gas flow through both single and multistage axial compressors. The end objective is to determine axial compressor characteristics with helium gas and to supplement the compressor design procedure by test results. The gas bearing development will address those problems incurred in the design of gas film bearings for the gas turbine powerplant, i.e., shock and vibrations conditions under test evaluations which will extend steady state design theory by including dynamic effects.

077-10576-620-27

THIN FILM HYDRODYNAMICS

(*b*) Wright Patterson Air Force Base, Air Force Aero-Propulsion Laboratory.
(*c*) Jed A. Walowit, Manager.
(*d*) Experimental and theoretical research.
(*e*) A theoretical and experimental investigation of very thin lubricant films under conditions of high load, speed and shear rate simulating those occurring in concentrated contact elements such as ball and roller bearings, gears, cams and rolling contact drives.
(*f*) Completed.
(*g*) Traction characteristics were measured and characterized with semiempirical relationships. Comparisons were obtained between theoretical film thickness predictions and measurements obtained by both optical and capacitive techniques. Results of research showed that conventional viscometric measurements do not characterize adequately the lubricant properties and need to be supplemented by measuring effective viscosity under conditions of high pressure and shear rate.
(*h*) **Elastohydrodynamic Lubrication,** J. M. McGrew, A. Gu, H. S. Cheng, S. F. Murray, *AFAPL-TR-70-27*, 11/70.
Research on Elastohydrodynamic Lubrication of High Speed Rolling-Sliding Contacts, R. L. Smith, J. A. Walowit, P. K. Gupta, J. M. McGrew, *AFAPL-TR-71-54*, 12/71.
Research on Elastohydrodynamic Lubrication of High Speed Rolling-Sliding Contacts, R. L. Smith, J. A. Walowit, P. K. Gupta, J. M. McGrew, *AFAPL-TR-72-56*.
Elastohydrodynamic Traction Characteristics of SP4E Polyphenyl Ether, R. L. Smith, J. A. Walowit, J. M. McGrew, *ASME J. Lub. Tech.* **95,** 3, pp. 353-362, 7/73.
Traction Characteristics of a MIL-L-7808 Oil, J. A. Walowit, R. L. Smith, *ASME J. Lub. Tech.* **98,** Ser. F, 4, pp. 607-612, 10/76.

UNIVERSITY OF MIAMI, Department of Mechanical Engineering, School of Engineering and Environmental Design, P.O. Box 248294, Coral Gables, Fla. 33129.

078-09023-870-50

REMOTE SENSING APPLIED TO NUMERICAL MODELING OF THERMAL POLLUTION

(*b*) NASA-Kennedy Space Center.
(*c*) Samuel S. Lee, Ph.D. and Subrata Sengupta, Ph.D.
(*d*) Theoretical, field experiments, applied numerical.
(*e*) A generalized three-dimensional, predictive, numerical model package for analyzing thermal discharges from power plants is being developed. The model package can be applied to near-field thermal effects as well as basin wide effects. Remote sensors from aircraft and satellites are used to provide data for, boundary conditions, calibration and verification. Ground truth and *in-situ* measurements provide the necessary temperature and velocity fields for this integrated approach to thermal pollution modeling. Sites in Biscayne Bay in south Florida and Hutchinson Island in central Florida have been modeled. The models simulate effects of wind, tide, discharges, meteorological parameters and bottom topography.
(*g*) The rigid-lid model has been verified for near-field studies of thermal discharges. Far-field versions of the model have been verified for velocity and temperature fields in Biscayne Bay. The free-surface model has been verified in Biscayne Bay and Hutchinson Island.
(*h*) **Three-Dimensional Thermal Pollution Models,** S. Lee, S. Sengupta, *NASA-CR-144858*.
Three-Dimensional Model Development for Thermal Pollution Studies, *Proc. Conf. Environmental Modeling and Simulation*, Cincinnati, 1976.

078-09832-870-50

APPLICATION OF NUMERICAL MODELING AND REMOTE SENSING FOR THERMAL DISCHARGE ANALYSIS IN LAKE BELEWS

(*b*) NASA-Kennedy Space Center.
(*c*) Samuel S. Lee, Ph.D. and Subrata Sengupta, Ph.D.
(*d*) Applied numerical, field experiments.

(*e*) A generalized three-dimensional, rigid-lid model has been used to study the heat and mass transport in Belews Lake, N.C. Discharges from a power plant of Duke Power Company has been modeled. Model calibration and verification efforts have used extensive remote sensed data from airborne thermal scanners. Ground truth and *in-situ* measurements for velocity and temperature have provided the necessary three-dimensional data base.
(*g*) Four field experiments covering the seasonal cycle have been completed; calibration and verification of model is ongoing.
(*h*) **Three-Dimensional Modeling of Thermal Discharges into Lake Belews,** S. S. Lee, S. Sengupta, *Mid-Term Report*.

MICHIGAN STATE UNIVERSITY, College of Engineering, Department of Civil Engineering, East Lansing, Mich. 48824. Dr. William C. Taylor, Chairman.

079-0416W-870-00

EVAPOTRANSPIRATION AT A WASTEWATER SPRAY SITE

(*e*) See WRRC 2, 2.0107.

079-08777-210-54

THE EFFECT OF RELEASED GASES ON HYDRAULIC TRANSIENTS

(*b*) National Science Foundation.
(*c*) David C. Wiggert, Assoc. Professor.
(*d*) Experimental and applied numerical research including Master's thesis.
(*e*) Investigation of hydraulic transient response with gas released from liquid in a long pipeline. Includes experimental study with gaseous cavitation in a pipe loop, and numerical modeling of two-component transient flow.
(*f*) Due for completion August 1977.
(*g*) Experimental work completed. Significant gas release is encountered with initial dissolved gas contents ranging from 50 to 200 percent by volume. Numerical analysis based on the method of characteristics satisfactorily predicts the transient phenomenon.
(*h*) **Pressure Wave Propagation in Two-Phase Bubbly Air-Water Mixtures,** C. S. Martin, K. Padmanabhan, D. C. Wiggert, *Proc. 2nd Intl. Conf. on Pressure Surges*, Sept. 1976.
Some Observations Concerning Gas Release in Unsteady Flow, D. C. Wiggert, *3rd Intl. Conf. Water Column Separation*, May 1976.

MICHIGAN STATE UNIVERSITY, College of Engineering, Department of Mechanical Engineering, East Lansing, Mich. 48824. Dr. J. F. Foss.

081-08990-020-22

THE INFLUENCE OF MOLECULAR DIFFUSIVITY IN TURBULENT MIXING

(*b*) Project SQUID.
(*c*) J. F. Foss.
(*d*) Experimental; basic; Ph.D. thesis.
(*e*) Species concentration measurements for both diffusive and non-diffusive gases inside a closed mixing chamber will be made by light scattering techniques; the comparison of these results will reveal the influence of molecular diffusivity for uniform and non-uniform distributions of the fluid densities and turbulence field. Results obtained to date include measures of the non-diffusive mixing of air/air and Freon 12/Freon 12 at $UM/\nu = 10^4$ and 6×10^4 respectively. (Non-diffusive: the lower gas volume was marked with submicron particulate matter.)
(*f*) Suspended.
(*g*) The present results suggest that the low viscosity Freon gas involves non-diffusive mixing (spatial striations) scales of a size smaller than the 0.2 diameter $\times$ 0.35 length cylindrical scattering volume. A comparison of width measures from the ensemble mean and instantaneous scans suggests that the mixed region is relatively narrow and is laterally transported by the large scale convective action to achieve the observed mean values.

081-10609-010-50

EFFECT OF LAMINAR/TURBULENT BOUNDARY LAYER STATE ON DEVELOPMENT OF SHEAR LAYER

(*b*) NASA Langley.
(*c*) J. F. Foss.
(*d*) Experimental, basic.
(*e*) For otherwise identical experimental conditions ($U = 20$ mps), the effects of a laminar and a turbulent boundary layer at the initiation of a shear layer were evaluated via $\bar{u}$ and $\widetilde{u'}$ measurements. Pronounced differences in the development region were observed; the flow appeared to lose the influence of its origin conditions.
(*f*) Completed.
(*h*) **The Effects of the Laminar/Turbulent Boundary Layer States on the Development of a Plane Mixing Layer,** *Symposium on Turbulent Shear Flows*, pp. 11. 33, The Pennsylvania State University, Apr. 18-20, 1977.

081-10610-700-50

VORTICITY MEASUREMENTS

(*b*) NASA Langley Research Center.
(*c*) J. F. Foss.
(*d*) Experiments (supporting analysis) basic.
(*e*) Fabrication of probes and development of computing algorithms to utilize adjacent x and parallel hot-wire arrays to infer the transverse vorticity in a shear flow is in progress. The desired result is to obtain a high rate (50,000 samples/sec) time series for $\partial u/\partial y - \partial v/\partial x$). Parallel electronics work is in progress to allow a real time calculation with a special purpose digital processor.
(*g*) Initial measurement achieved, second iteration to gain precise ($\partial\bar{u}/\partial y$) in progress.

081-10611-050-50

OBLIQUE JET IMPINGEMENT FLOW

(*b*) NASA Langley Research Center.
(*c*) J. F. Foss.
(*d*) Experimental; basic.
(*e*) The far field acoustic noise from the impinging jet flow is considered as a function of the vorticity structure in the impact region of the flow. A digital electronics circuit to process four hot-wire signals from which two velocity components and the transverse vorticity can be extracted is under development. Mean flow measurements for 45 degree and more shallow impingement angles have been acquired. Results obtained to date include measures of the non-diffusive mixing of for air/air and Freon 12/Freon 12 at $UM/V = 10^4$ and 6×10^4 respectively. (Non-diffusive: the lower gas volume was marked with submicron particulate matter.)
(*f*) Suspended.
(*g*) The present results suggest that the low viscosity Freon gas involves non-diffusive mixing (spatial striations) scales of a size smaller than the 0.2 diameter $\times$ 0.35 length cylindrical scattering volume. A comparison of width measures from the ensemble mean and instantaneous scans suggests that the mixed region is relatively narrow and is laterally transported by the large scale convective action to achieve the observed mean values.

254-330 O - 78 - 7

UNIVERSITY OF MICHIGAN, College of Engineering, Department of Aerospace Engineering, Ann Arbor, Mich. 48104. Professor R. M. Howe, Department Chairman.

082-07442-010-20

AN INVESTIGATION OF WALL PRESSURE FLUCTUATIONS AND STRUCTURE OF A TURBULENT BOUNDARY LAYER

(*b*) Office of Naval Research and National Science Foundation.
(*c*) Professor William W. Willmarth.
(*d*) Experimental, basic research, Doctoral thesis.
(*e*) Fluctuating velocity and pressure measurements in and beneath turbulent boundary layers on cylinders and plane surfaces. Purpose is basic research on turbulence.
(*g*) Study of mean velocity profiles, wall shear stress and wall pressures beneath boundary layers on cylinders primarily aligned with the flow in order to reveal the effect of transverse curvature and slight cross flow velocities produced by yaw and free stream turbulence. Measurements of the small scale structure of turbulence are also being carried out using extremely small scale hot wires.
(*h*) **Structure of Turbulence in Boundary Layers,** W. W. Willmarth, *Advances in Applied Mechanics* **15,** ed. C. S. Yih, 159 pages, 1975.
Axially Symmetric Turbulent Boundary Layers on Cylinders: Mean Velocity Profiles and Wall Pressure Fluctuations, W. W. Willmarth, R. E. Winkel, L. K. Sharma, T. J. Bogar, *J. Fluid Mech.* **76,** 1, p. 35, 1976.
The Effect of Cross Flow and Isolated Roughness Elements on the Boundary Layer and Wall Pressure Fluctuations on Circular Cylinders, W. W. Willmarth, L. K. Sharma, S. Inglis, *Rept. 014439-01*, Univ. of Michigan, Dept. of Aerospace Engrg., Jan. 1977.

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UNIVERSITY OF MICHIGAN, College of Engineering, Department of Applied Mechanics and Engineering Science, Ann Arbor, Mich. 48109. Professor W. P. Graebel, Acting Department Chairman.

083-08604-060-20

STRATIFIED FLOWS

(*b*) Office of Naval Research.
(*c*) Professor C.-S. Yih.
(*d*) Basic research, mainly theoretical.
(*e*) All aspects of stratified flows.
(*h*) **Vortices and Vortex Rings of Stratified Fluids,** *J. Applied Mathematics, SIAM* **28,** pp. 899-912, 1975.
Comparison Theorems for Water Waves in Basins of Variable Depth, *Quar. Applied Math.* **33,** pp. 387-394, 1976.
Internal Waves in Pipes, *J. Hydraulic Research* **13,** 3, pp. 329-342, 1975.
Internal Waves in Circular Channels (with W.-H. Yang), *J. Fluid Mechanics* **74,** pp. 183-192, 1976.
Instability of Surface and Internal Waves, *Advances in Applied Mechanics* **16,** pp. 369-419, 1976.

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UNIVERSITY OF MICHIGAN, Department of Chemical Engineering, Ann Arbor, Mich. 48109. Professor H. S. Fogler.

084-09818-130-00

ACOUSTIC EMULSIFICATION (I)

(*d*) Theoretical and experimental.
(*e*) A technique has been developed to study the phenomenon of acoustic emulsification in which oil is dispersed as a fine suspension into water at 20 kHz. The acoustic emulsification process takes place in two stages. In the first stage, large oil droplets are formed from eruption of surface waves at the oil-water interface. In the second stage acoustic cavitation causes these large drops to break up into smaller drops.
The criterion of instability for the initial stage of emulsification has been derived from a linearized stability analysis of the oil-water interface under acoustic excitation. The characteristic droplet diameter produced by the instability is related to the induced capillary wavelength at the interface. The theoretical threshold amplitude of vibration necessary for the instability of the interfacial waves and the ultrasonic transducer amplitude are virtually the same. In addition the size of the large droplets present in the suspension systems at short irradiation times agree closely with the predicted droplet diameters.
It is known that intense cavitational shockwaves can be generated in the water medium under the influence of an ultrasonic field. In conjunction with the liquid-liquid emulsification phenomenon, a theoretical model for the deformation and break-up of an oil droplet was examined on the basis of the droplet being exposed to a cavitation shock. A relation from the model is expressed in terms of two dimensionless quantities, the Ohnesorge number and the critical Weber number ratio. These values, are then plotted and compared with the ones obtained from the studies on the liquid droplet exposed to shock impact from a gas stream, and the remarkable agreement leads one to the conclusion that large oil droplets originally formed from the oil-water interface as a result of the instability were disintegrated into smaller ones by the cavitation force until a critical size, characteristic of the oil-water system is reached.
(*h*) **Ultrasonic Emulsification,** M. Li, *Ph.D. Thesis*, Univ. of Michigan, 1976.

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UNIVERSITY OF MICHIGAN, College of Engineering, Department of Civil Engineering, Ann Arbor, Mich. 48104. Dr. E. F. Brater, Professor of Hydraulic Engineering.

085-08850-410-60

A STUDY OF SHORE PROTECTION PROCEDURES

(*b*) Michigan Department of Natural Resources and NOAA Sea Grant Program.
(*d*) Laboratory and field investigation.
(*e*) The effectiveness and durability of various shore protection procedures are being investigated.
(*g*) The effectiveness of various shore protection procedures have been compared with unprotected conditions.
(*h*) **Laboratory Investigation of Shore Erosion Process,** presented *15th Intl. Conf. on Coastal Engrg.*, July 1977.

085-08851-070-54

NONLINEAR SATURATED SOIL MOTIONS RESULTING FROM EARTHQUAKES

(*b*) National Science Foundation.
(*c*) Professors V. L. Streeter, E. B. Wylie.
(*d*) Theoretical; applied research.
(*e*) Study of liquefaction of soils during seismic activity.
(*h*) **Characteristics Method for Liquefaction of Soils,** E. B. Wylie, V. L. Streeter, *Conf. on Numerical Methods in Geomechanics*, VPI, Va., pp. 938-954, June 1976.
A Numerical Method for Liquefaction in Sand Deposits, C. P. Liou, *Ph.D. Thesis*, submitted to the Univ. of Michigan, Apr. 1976.

085-08853-210-54

TRANSIENT FLOW THROUGH OPEN AND CLOSED CONDUITS

(*c*) Professors V. L. Streeter, E. B. Wylie.

(*e*) Study of unsteady fluid flow in pipes and liquid flow in open channels.
(*h*) **Waterhammer Analysis with Air Release,** J. P. Tullis, V. L. Streeter, E. B. Wylie, *2nd Intl. Conf. on Pressure Surges*, BHRA, Bedford, England, Sept. 1976.
Fluid Transients, E. B. Wylie, V. L. Streeter, McGraw-Hill Book Co., 1977.

085-08854-820-00

TRANSIENT FLOW IN AQUIFERS

(*c*) Professor E. B. Wylie.
(*d*) Development.
(*f*) Complete.
(*h*) **Transient Aquifer Flows by Characteristics Method,** E. B. Wylie, *ASCE, J. Hyd. Div.* **102,** HY3, pp. 293-305, Mar. 1976.
Numerical Predictions of Two-Dimensional Transient Groundwater Flow by Method of Characteristics, D. C. Wiggert, E. B. Wylie, *Water Resources Research* **12,** 5, pp. 971-977, Oct. 1976.

085-09994-420-00

FORCES DUE TO WAVES AND CURRENTS ON RUBBLE COVERING PIPES BURIED IN OCEAN OR LAKE BOTTOMS

(*b*) University Research Funds.
(*c*) Professor E. F. Brater.
(*d*) For Doctoral thesis.
(*e*) The development of design criteria for cover layers exposed to waves and currents.

085-09995-390-54

NONLINEAR SHEAR WAVE PROPAGATION IN SOILS

(*b*) National Science Foundation.
(*c*) Professors V. L. Streeter, E. B. Wylie.
(*d*) Theoretical, applied research.
(*e*) Study of one-dimensional shear wave transmission in layered soils.
(*h*) **One-Dimensional Soil Transients by Characteristics,** E. B. Wylie, V. L. Streeter, *Conf. on Numerical Methods in Geomechanics*, VPI, Va., June 1976.
Influence of Dynamic Soil Properties on Response of Soil Masses, F. E. Richart, E. B. Wylie, *Structural and Geotechnical Mechanics*, pp. 141-162, Prentice Hall, N.J., 1977.

UNIVERSITY OF MICHIGAN, Cavitation and Multiphase Flow Laboratory, Department of Mechanical Engineering, Ann Arbor, Mich. 48109. Frederick G. Hammitt, Professor-in-Charge (reports on all projects available by writing to laboratory).

086-06147-230-54

BUBBLE NUCLEATION, GROWTH AND COLLAPSE PHENOMENA

(*b*) Office of Naval Research and Industry.
(*d*) Theoretical and experimental; basic research for various Ph.D. theses.
(*e*) Study of the details of inception, growth and collapse of vapor and gas bubbles in liquids. This has included the development of methods for measuring entrained gas microbubble spectra in water and correlating with cavitation nucleation pressure thresholds. Effects of fast neutron irradiation and strong magnetic fields have been included along with variation of temperature, pressure, settling-time, total gas content, etc. Present work emphasizes acoustic bubble collapse measurements and correlation with measured erosion rates.

086-08123-230-70

CAVITATION EROSION TESTING

(*b*) ONR and Industry.
(*e*) Measurement of chemical vs. mechanical effects in cavitation erosion as well as other details of erosion process.

086-08779-130-54

WET STEAM FLOWS

(*b*) National Science Foundation.
(*d*) Experimental and theoretical Ph.D. theses research.
(*e*) Experimental and theoretical investigation of low pressure wet steam flows (pertinent to low pressure end of large steam turbines) across blading profiles. Includes measurement of liquid film thicknesses on profiles, and downstream droplet size, velocity and population distributions, as well as theoretical studies of liquid film stability under high-velocity steam flows. Downstream liquid particle size and velocity distributions can be used as input for our droplet impact erosion work described in the previous project description.

UNIVERSITY OF MICHIGAN, Department of Naval Architecture and Marine Engineering, Ann Arbor, Mich. 48104. T. Francis Ogilvie, Chairman.

087-09866-520-22

SHIP MOTIONS IN SHALLOW WATER

(*b*) General Hydromechanics Research Program, Naval Ship Systems Command.
(*c*) Armin Troesch, Robert Beck.
(*d*) Experimental and theoretical.
(*c*) Experiments were conducted on a model in shallow water and the results were compared with theory. Special attention was paid to the problems of wave generation.
(*f*) Completed.
(*g*) Experiments and theory do not compare well, possibly because of non-linear effects.
(*h*) **Experiments on Ship Motions in Shallow Water,** A. Troesch, R. F. Beck, *Rept. 149*, Dept. Naval Architecture and Marine Engrg., Mar. 1974.

087-09867-520-22

ANALYSIS OF A TWO-DIMENSIONAL CAPTURED AIR BUBBLE

(*b*) General Hydromechanics Research Program, Naval Ship Systems Command.
(*c*) Susan Atkins.
(*d*) Experimental.
(*e*) The prediction of the added mass and damping of a heaving two-dimensional, captured air bubble is verified, within limits. The results are applicable to the motions of an air cushion vehicle (ACV).
(*f*) Completed.
(*g*) Only the depth of the lip, relative to the width of the bubble, appears to exert a strong influence on the results.
(*h*) **Experimental Analysis of a Two-Dimensional Captured Air Bubble,** S. O. Atkins, *Rept. 166*, Dept. Naval Architecture and Marine Engrg., Dec. 1974, $1.25.

087-09868-520-54

FORCES AND MOMENTS ON A SHIP MOVING IN A CANAL

(*b*) National Science Foundation.
(*c*) Robert F. Beck.
(*d*) Theoretical, basic research.
(*e*) The method of matched asymptotic expansions is applied to the problem of a ship moving with constant velocity in a channel of rectangular cross section.
(*f*) Completed.
(*g*) Numerical results show good agreement with experiments.

(*h*) **Forces and Moments on a Ship Moving in a Canal,** R. F. Beck, *Rept. 179,* Dept. Naval Architecture and Marine Engrg., $3.00.

087-09869-520-54

SHIP MANEUVERING IN SHALLOW WATERS

(*b*) National Science Foundation.
(*c*) Nabil Daoud, T. Francis Ogilvie.
(*d*) Experimental, theoretical, basic research.
(*e*) Both an experimental and analytical approach to the problem of ship operations in restricted waters is being undertaken. Shallow water effects on maneuverability are significant and the purpose of this research is to understand these problems more fully.
(*g*) Experiments and theoretical calculations show the clearance between the ship's hull and the sea bottom is an important factor in the stability of the vessel.
(*h*) **Maneuverability in Restricted Waters: State of the Art,** M. Fujino, *Rept. 184,* Dept. Naval Architecture and Marine Engrg., Aug. 1976, $5.00.

UNIVERSITY OF MINNESOTA, Department of Aerospace Engineering and Mechanics, Minneapolis, Minn. 55455. Professor P. R. Sethna, Department Head.

088-07488-000-54

HYDRODYNAMIC STABILITY

(*b*) National Science Foundation.
(*c*) Professor Daniel D. Joseph.
(*d*) Theoretical; basic research; M.S., Ph.D. theses.
(*e*) Theoretical research on the stability of a broad class of fluid motions.
(*g*) The implications of energy analysis for the stability of classical motions (Couette and Poiseuille flows in annuli, pipes, channels, etc., and variations on the Benard problem) are emphasized. A global theory of stability is sought in which linear theory, energy theory and the theory of branching solutions of the Navier-Stokes equations play unique and complementary roles. Also developed are aspects of near-linear perturbation theories.
(*h*) **Nonlinear Diffusion Induced by Nonlinear Sources,** D. D. Joseph, E. M. Sparrow, *Quart. Appl. Math.* **XXVIII,** pp. 327-342, Oct. 1970.
Stability of Convection in Containers of Arbitrary Shape, D. D. Joseph, *J. Fluid Mech.* **47,** pp. 257-282, 1971.
Quasilinear Dirichlet Problems Driven by Positive Nonlinear Sources, D. D. Joseph, T. S. Lundgren, *Arch. Rat. Mech. Anal.* **46,** pp. 241-269, 1973.
Contributions to the Nonlinear Theory of Stability of Viscous Flow in Pipes and Between Rotating Cylinders, D. D. Joseph, W. Hung, *Arch. Rat. Mech. Anal.* **44,** pp. 1-22, 1971.
Global Stability of Spiral Flow, Part II, D. D. Joseph, W. Hung, B. Munson, *J. Fluid Mech.* **51,** pp. 593–612, 1972.
Viscous Incompressible Flow Between Concentric Rotating Spheres: Part I, Basic Flow, D. D. Joseph, B. Munson, *J. Fluid Mech.* **49,** pp. 289-303, 1971.
Viscous Incompressible Flow Between Concentric Rotating Spheres: Part II, Hydrodynamic Stability, D. D. Joseph, B. Munson, *J. Fluid Mech.* **49,** pp. 305-318, 1971.
Heat Transport in a Porous Layer, F. H. Busse, D. D. Joseph, *J. Fluid Mech.* **54,** 3, pp. 521-543, 1972.
Bifurcating Time Periodic Solutions and Their Stability, D. D. Joseph, D. Sattinger, *Arch. Rat. Mech. Anal.* **45,** pp. 79-109, 1972.
Subcritical Bifurcation of Plane Poiseuille Flow, D. D. Joseph, T. S. Chen, *J. Fluid Mech.* **58,** p. 337, Apr. 1973.
Remarks About Bifurcation and Stability of Quasi-Periodic Solutions Which Bifurcate from Periodic Solutions of the Navier-Stokes Equations, in *Nonlinear Problems in Physical Science and Engineering,* Springer Lecture Notes in Mathematics (Ed. Stakgold, Joseph and Sattinger), 1973.
Heat Transport in a Porous Layer, D. D. Joseph, V. Gupta, *J. Fluid Mech.* **57,** p. 521, 1973.
Energy Theory of Hydromagnetic Flow, D. D. Joseph, *Proc. Conf. on Mathematical Topics in Stability Theory,* Washington State Univ., 1972.
Domain Perturbations: The Higher Order Theory of Infinitesimal Water Waves, *Arch. Rational Mech. Anal.* **51,** p. 295, 1973.
Friction Factors in the Theory of Bifurcating Poiseuille Flow Through Annular Ducts, D. D. Joseph, T. S. Chen, *J. Fluid Mech.* **65,** p. 189., 1974.
Response Curves for Plane Poiseuille Flow, D. D. Joseph, in *Advances in Applied Mechanics* **XIV,** (Ed.: C. S. Yih), Academic Press, New York, 1974.
Repeated Supercritical Branching of Solutions Arising in the Variational Theory of Turbulence, *Arch. Rational Mech. Anal.* **53,** p. 101, 1974.

088-07489-020-54

THEORETICAL RESEARCH ON TURBULENCE

(*b*) National Science Foundation.
(*c*) Professor T. S. Lundgren.
(*d*) Theoretical basic research; M.S., Ph.D. theses.
(*e*) Appropriate closure hypotheses are sought for hydrodynamic turbulence.
(*f*) Completed.
(*g*) The work centered on the statistical mechanics of two dimensional vortices as a model for two-dimensional turbulence. A second area of interest was turbulent diffusion.
(*h*) **Statistical Mechanics of Two-Dimensional Vortices,** T. S. Lundgren, Y. B. Pointin, *J. Stat. Phys.* **17** (1977).
Equation of State of a Vortex Fluid, Y. B. Pointin, T. S. Lundgren, *Physical Review A* **13,** pp. 1274-1275 (1976).
Statistical Mechanics of Two-Dimensional Vortices in a Bounded Container, Y. B. Pointin, T. S. Lundgren, *Phys. Fluids* **19,** pp. 1459-1470 (1976).
Non-Gaussian Probability Distributions for a Vortex Fluid, T. S. Lundgren, Y. B. Pointin, *Phys. Fluids* **20,** pp. 356-363 (1977).
Turbulent Self-Diffusion, T. S. Lundgren, Y. B. Pointin, *Phys. Fluids* **19,** pp. 355-358 (1976).

088-08859-120-14

STUDIES IN THE VISCOMETRY OF SLOW MOTIONS OF RHEOLOGICALLY COMPLEX LIQUIDS

(*b*) U.S. Army Research Office.
(*c*) Professors D. D. Joseph, G. S. Beavers.
(*d*) Theoretical and experimental; basic and applied research; M.S., Ph.D. theses.
(*e*) Experimental and mathematical studies of the mechanics of flow of rheologically complex liquids are being carried out. The immediate aim is to enrich the science and technology of viscometry by developing sets of standard experiments, founded on sound mathematical analysis, which will lead to reliable viscometric data characterizing the slow motion of rheologically complex fluids. There is also interest in certain mathematical studies of the mechanical foundations of rheology and in the evolution of new methods of analysis.
(*g*) The following projects are active: (1) The rotating rod viscometer. (2) The Tilted Trough Viscometer. (3) Hele-Shaw flows. (4) Free surface viscometers driven by thermal convection. (5) Torsion flow viscometry.
(*h*) **The Free Surface on a Liquid Between Cylinders Rotating at Different Speeds–Part I,** D. D. Joseph, R. Fosdick, *Arch. Rat. Mech. Anal.* **49,** pp. 321-380, 1973.
The Free Surface on a Liquid Between Cylinders Rotating at Different Speeds–Part II, D. D. Joseph, G. S. Beavers, R. Fosdick, *Arch. Rational Mech. Anal.* **49,** pp. 381-401, 1973.
Tall Taylor Cells in Polyacrylamide Solutions, G. S. Beavers, D. D. Joseph, *Physics of Fluids* **19,** p. 650, 1974.

Slow Motion and Viscometric Motion; Stability and Bifurcation of the Rest State of a Simple Fluid, D. D. Joseph, *Arch. Rational Mech. Anal.* **56,** 2, pp. 99-157, 1974.
The Free Surface on a Liquid Filling a Trench Heated From Its Side, D. D. Joseph, L. Sturges, *J. Fluid Mech.* **69,** 3, pp. 565-589, 1975.
The Rotating Rod Viscometer, G. S. Beavers, D. D. Joseph, *J. of Fluid Mech.* **69,** 3, pp. 475-511, 1975.
Slow Motion and Viscometeric Motion. Part V: The Free Surface on a Simple Fluid Flowing Down a Tilted Trough, L. Sturges, D. D. Joseph, *Arch. Rational Mech. Anal.* **59,** 4, pp. 359-387, 1975.
The Free Surface on a Simple Fluid Between Cylinders Undergoing Torsional Oscillations, D. D. Joseph, G. S. Beavers, *Arch. Rational Mech. Anal.* **62,** 4, pp. 323-352, 1976.
Novel Weissenberg Effects, G. S. Beavers, D. D. Joseph, *J. Fluid Mech.* **81,** 2, pp. 265-273, 1977.

088-08860-000-70

ROTATING FLOWS

(*b*) Union Carbide Corporation, Nuclear Division.
(*c*) Professors A. S. Berman, T. S. Lundgren.
(*d*) Theoretical and experimental; basic research; M.S., Ph.D. theses.
(*e*) Study of spin up with and without density stratification and free surfaces.

088-10573-070-54

FLUID FLOW THROUGH DEFORMABLE POROUS MEDIA

(*b*) National Science Foundation.
(*c*) Professor Gordon S. Beavers.
(*d*) Theoretical and experimental; basic and applied research; M.S., Ph.D. theses.
(*e*) The project aims to formulate and test mathematical models which will be capable of predicting the flow through deformable porous media, and which can be used for incompressible and compressible flows through many types of deformable media for geometries involving more than one principal flow direction.
(*g*) A model, based on the Forchheimer extension of the Darcy Law for flows through incompressible media, has been developed to describe the one-dimensional flow of an incompressible fluid through a deformable porous material. Mass flow rate predictions of the model agree well with experimental observations.
(*h*) **Compressible Gas Flow Through a Porous Material,** G. S. Beavers, E. M. Sparrow, *Intl. J. Heat and Mass Transfer* **14,** 11, pp. 1855-1857, 1971.
Experiments on the Resistance Law for Non-Darcy Compressible Gas Flows in Porous Media, *J. Fluids Engrg., Trans ASME* **96,** Series I, 4, pp. 353-357, 1974.
Flow Through a Deformable Porous Material, G. S. Beavers, T. A. Wilson, B. A. Masha, *J. Appl. Mech.* **42,** *Trans. ASME* **97,** Series E, pp. 598-602, 1975.

UNIVERSITY OF MINNESOTA, St. Anthony Falls Hydraulic Laboratory **(see ST. ANTHONY FALLS HYDRAULIC LABORATORY listing).**

MISSISSIPPI STATE UNIVERSITY, Department of Aerophysics and Aerospace Engineering, Mississippi State, Miss. 39762. Professor C. B. Cliett, Department Head.

089-10135-530-20

NUMERICAL SOLUTION OF THE NAVIER-STOKES EQUATIONS FOR 2D HYDROFOILS

(*b*) Office of Naval Research.
(*c*) Dr. Joe F. Thompson, Professor.
(*d*) Basic research, M.S. and Ph.D. theses.
(*e*) A finite-difference solution of the full time-dependent, incompressible Navier-Stokes equations with gravity forces included was developed for laminar flow about a 2D hydrofoil of arbitrary shape below or in a free surface.
(*f*) Completed.
(*g*) The numerical solution uses boundary-fitted curvilinear coordinate system generated numerically from two coupled elliptic partial differential equations for the coordinates. This coordinate system maintains coordinate lines coincident with the deforming free surface and with the arbitrary hydrofoil contour while allowing all computations to be done on a fixed square mesh in the transformed field. The hydrofoil may be in pitching, plunging, or longitudinal oscillation as well as translation. Results were obtained for Reynolds numbers up to 100, but the solution is thought to be extendable to higher Reynolds numbers.
(*h*) **Numerical Solution of the Navier-Stokes Equations for 2D Hydrofoils In or Below a Free Surface,** S. P. Shanks, J. F. Thompson, *Proc. 2nd Intl. Conf. Numerical Ship Hydrodynamics*, Berkely, Calif., 1977.
Numerical Solution of the Navier-Stokes Equations for 2D Hydrofoils, J. F. Thompson, S. P. Shanks, R. L. Walker, *MSSU-EIRS-ASE-77-5*, Engrg. and Industrial Research Station, Mississippi State Univ., 1977.

089-10136-030-26

NUMERICAL SOLUTION OF THE MEAN TURBULENT FLOW EQUATIONS

(*b*) Air Force Office of Scientific Research.
(*c*) Dr. Z. U. A. Warsi, Assoc. Professor.
(*d*) Basic research, Ph.D. thesis.
(*e*) Solve the complete mean turbulent shear flow equations for incompressible flows past arbitrary two-dimensional bodies. A method of numerical coordinate transformation has been utilized to solve the model equations of momentum and energy along with the equation of continuity.
(*g*) Model equations of Kolmogorov and Saffman have been transformed tensorially to a general coordinate system. This general coordinate system is made specific by numerically generating a non-orthogonal coordinate system which depends on the body contour past which the flow takes place and an outer boundary which is assumed to be at infinity. The problems of mean turbulent flow past a circular cylinder started impulsively from rest and of the steady flow past on NACA airfoil are under investigation.
(*h*) **Numerical Solutions for Laminar and Turbulent-Viscous Flow over Single and Multi-Element Airfoils Using Body-Fitted Coordinate Systems,** J. F. Thompson, Z. U. A. Warsi, B. B. Amlicke, *Advances in Engineering Science, 13th Ann. Mtg. Engrg. Science*, Hampton, Va., Nov. 1-3, 1976. Published in vol. 4 as *NASA CP-2001*, pp. 1397-1408.
Improve Algebraic Relation for the Calculation of Reynolds Stresses, Z. U. A. Warsi, B. B. Amlicke, *AIAA J.* **14,** 12, pp. 1779-1781 (1976).
Machine Solutions of Partial Differential Equations in the Numerically Generated Coordinate Systems, Z. U. A. Warsi, J. F. Thompson, *MSSU-EIRS-ASE-77-1*, Engrg. and Industrial Research Station, Mississippi State Univ., 1976.
Structure of The Near-Wall Region In A Turbulent Flow, Z. U. A. Warsi, B. B. Amlicke, *MSSU-EIRS-ASE-77-3*, Engrg. and Industrial Research Station, Mississippi State Univ., 1976.

089-10137-000-26

DEVELOPMENT OF PARTIAL CHANNEL FLOW FOR ARBITRARY INPUT VELOCITY DISTRIBUTIONS USING BOUNDARY-FITTED COORDINATE SYSTEMS

(*b*) U.S. Army Research Office.
(*c*) Leslie R. Heater, Assoc. Professor.
(*d*) Basic research, Ph.D. thesis.
(*e*) Work consists of applying the technique of boundary-fitted coordinate systems to the solution of the Navier-Stokes

equations for partial channel flow. The boundary-fitted coordinate system provides a method whereby a rectangular grid in a transformed plane can be obtained for any channel configuration in the physical plane. The Navier-Stokes equations are then solved on the rectangular grid in the transformed plane. This eliminates the need for interpolation on the boundaries and the channel configuration the physical plane is merely an input into the program. An additional feature of this numerical procedure provides for a concentration of coordinate lines in the areas of flow where viscous effects are expected to dominate.

(*g*) The work thus far has dealt with applying this numerical procedure to a partial channel configuration that consists of a main channel flow that splits into a two channel flow and various combinations of input and output ports located on either side of the main channel flow. The numerical solution of the Navier-Stokes equations for two dimensional unsteady laminar flow has been obtained in the primitive variables of velocity and pressure. Comparison with experimental work is also underway.

089-10138-000-54

INTEGRO-DIFFERENTIAL NUMERICAL SOLUTION OF THE NAVIER-STOKES EQUATIONS

(*b*) National Science Foundation.
(*d*) Basic research, Ph.D. thesis.
(*e*) The technique of numerically-generated boundary-fitted coordinate systems was used with the integro-differential form of the Navier-Stokes to develop a finite-difference solution for time-dependent, incompressible laminar flow about arbitrary two-dimensional bodies.
(*f*) Completed.
(*g*) The integro-differential formulation allows all computation to be confined to the region of significant vorticity near the body and in the wake without losing the elliptic nature of the solution. The boundary-fitted coordinate system is generated numerically from two elliptic partial differential equations for the coordinates. This system maintains coordinate lines coincident with the arbitrary body contour and with the moving outer boundary of the expanding vorticity region while allowing all computation to be done on a fixed in the transformed field square mesh. Results were obtained at Reynolds numbers up to 10^6 for NACA airfoils.
(*h*) **Numerical Solution of Incompressible Navier-Stokes Equation in the Integro-Differential Formulation Using Boundary-Fitted Coordinate System,** R. N. Reddy, J. F. Thompson, *Proc. AIAA 3rd Computational Fluid Dynamics Conf.*, Albuquerque, N. Mex., 1977.

089-10139-000-50

NUMERICAL SOLUTION OF THE NAVIER-STOKES EQUATIONS FOR ARBITRARY TWO-DIMENSIONAL MULTI-ELEMENT AIRFOILS

(*b*) NASA, Langley Research Center.
(*d*) Applied research, Ph.D. theses.
(*e*) Numerically-generated boundary coordinate systems are being used to develop a finite-difference solution of the time-dependent, incompressible or compressible, Navier-Stokes equations for laminar flow about arbitrary two-dimensional airfoils.
(*g*) The boundary-fitted coordinate system is generated numerically by solving two coupled elliptic partial differential equations for the coordinates. This system allows all computation to be done on a square grid in the transformed plane regardless of the shape or number of bodies in the field. Results have been obtained for Reynolds numbers up to 10^6. A potential flow solution has also been developed.
(*h*) **Numerical Solutions for Viscous and Potential Flow about Arbitrary Two-Dimensional Bodies Using Body-Fitted Coordinate Systems,** F. C. Thames, J. F. Thompson, C. W. Mastin, R. L. Walker, accepted for publication in *J. Computational Physics*, (1977).
TOMCAT–A Code for Numerical Generation of Boundary-Fitted Curvilinear Coordinate Systems on Fields Containing Any Number of Arbitrary Two-Dimensional Bodies, J. F. Thompson, F. C. Thames, C. W. Mastin, accepted for publication in *J. Computational Physics*, 1977.
Numerical Solution of the Navier-Stokes Equations for Arbitrary Two-Dimensional Airfoils, F. C. Thames, J. F. Thompson, C. W. Mastin, *Proc. NASA Conf. Aerodynamic Analyses Requiring Advanced Computers, NASA SP-347*, Langley Research Center, 1975.
Numerical Solutions of the Unsteady Navier-Stokes Equations for Arbitrary Bodies Using Boundary-Fitted Curvilinear Coordinates, J. F. Thompson, F. C. Thames, R. L. Walker, S. P. Shanks, *Proc. Arizona/AFOSR Symp. Unsteady Aerodynamics*, Univ. of Arizona, 1975.
Use of Numerically Generated Body-Fitted Coordinate Systems for Solution of the Navier-Stokes Equations, J. F. Thompson, F. C. Thames, C. W. Mastin, S. P. Shanks, *Proc. AIAA 2nd Computational Fluid Dynamics Conf.*, Hartford, Conn., 1975.
Solutions of the Navier-Stokes Equations in Various Flow Regimes on Fields Containing Any Number of Arbitrary Bodies Using Boundary-Fitted Coordinate Systems, J. F. Thompson, F. C. Thames, S. P. Shanks, R. N. Reddy, C. W. Mastin, *Proc. V Intl. Conf. on Numerical Methods in Fluid Dynamics*, Enshede, The Netherlands, *Lecture Notes in Physics* **59**, Springer Verlag, 1976.
Boundary-Fitted Curvilinear Coordinate System for Solution of Partial Differential Equations on Fields Containing Any Number of Arbitrary Two-Dimensional Bodies, J. F. Thompson, F. C. Thames, C. W. Mastin, *NASA CR-2729*, 1977.
Numerical Solution of Potential Flow About Arbitrary Two-Dimensional Multiple Bodies, J. F. Thompson, F. C. Thames, *NASA CR*, to be published 1977.

089-10140-720-44

FLOW IMPROVEMENT MODIFICATIONS AND FLOW QUALITY EVALUATION OF THE NOIC CURRENT METER CALIBRATION FACILITY

(*b*) National Oceanographic Instrumentation Center, NOAA, Department of Commerce.
(*c*) Dr. George Bennett.
(*d*) The project is experimental. It should be classified as applied research. There was no thesis connected with the work.
(*e*) Improve the quality of the flow in the NOIC 15-inch diameter submerged jet current meter calibration facility. It had been determined that very large speed fluctuations (of order 10-30%) were present in the flow which was unacceptable for current meter calibration. The flow uniformity across the jet could not be determined due to the large fluctuations.
(*f*) Completed.
(*g*) Several modifications were made to the NOIC Current Meter Calibration Facility to reduce the large scale speed fluctuations and to improve the flow uniformity across the jet. The centerline speed fluctuations were reduced to ± 3 percent at 0.198 knots and near ± 1 percent over the speed range 0.487 to 4.31 knots. At 1.89 knots a level of ± 0.4 percent was achieved. Flow uniformity was to be well within the allowable 3 percent over the operating range except at 0.437 knots where a variation of 3.7 percent was found. The maximum jet speed achieved was 4.31 knots, 6 percent less than the specified 4.5 knots.
(*h*) **Flow Improvement Modifications and Flow Quality Evaluation of the NOIC Current Meter Calibration Facility,** G. Bennett, G. Wells, *EIRS-ASE-75-2*, College of Engrg., Miss. State Univ., Apr. 1975.

089-10141-720-44

TURBINE METER INSTALLATION AND FLOW VISUALIZATION DEVELOPMENT FOR THE NOIC CURRENT METER CALIBRATION FACILITY

(*b*) National Oceanographic Instrumentation Center, NOAA, Department of Commerce.
(*c*) Dr. George Bennett.

(*d*) The project is experimental. It should be classified as applied research. There was no thesis connected with the work.
(*e*) Further improve the utility of the NOIC Current Meter Calibration Facility through the installation of turbine flow meters for precise definition of jet flow speed and through the development of hydrogen bubble flow visualization equipment.
(*f*) Completed.
(*g*) The installation of the four turbine flow meters, flow straightening vanes, associated piping and jet speed indicators was accomplished. System calibration tests were conducted using an HP 9820 data acquisition system and a Delft reference current meter. It was found that the repeatability of the turbine meters was better than the Delft meter. However, more refined calibration of the reference current meter will be required before final precision jet speed versus turbine meter output frequency charts can be established. Both the hydrogen bubble and dye filament flow visualization techniques worked very well, due to the low turbulence levels in the jet. The persistence of the hydrogen bubbles exceeded all expectations. A control box was constructed to permit continuous and periodic hydrogen bubble filaments to be generated. A 1150 watt submersible slit light source was constructed to illuminate the hydrogen bubble and dye filaments.
(*h*) **Turbine Meter Installation and Flow Visualization Development for the NOIC Current Meter Calibration Facility,** G. Bennett, G. Wells, *MSSU-EIRS-ASE-77-2*, College of Engrg., Miss. State Univ., Sept. 1976.

UNIVERSITY OF MISSOURI-COLUMBIA, Department of Geology, Columbia, Miss. 65201. George W. Viele, Chairman.

091-10062-220-54

CONTINENTAL VOLCANICLASTICS, VOLCAN DE FUEGO, GUATEMALA

(*b*) National Science Foundation; Instituto Geografico Nacional, Guatemala.
(*c*) Professor David K. Davies.
(*d*) Field investigation, basic research.
(*e*) Investigation of debris flow and stream flow characteristics in an active volcanic region. The study seeks to determine length of time taken to erode the products of a single eruption; time taken for sediment being fluvially transported from the cones to the sea; nature of fluvial flow from the headwaters to the river mouths; mechanics of sediment transport (including boulders) in the fluvial system; and effect of fluvial transport on the composition and texture of the sediment load.
(*g*) Since the 1974 eruption of the volcano Fuego, Guatemala, some 25 million tons of sediment have been transported annually from the cone. Ejecta from this eruption will be completely eroded and fluvially transported from the volcanic highlands within approximately 10 years assuming no substantial revegetation. Individual flood surges on the Rio Guacalate have discharges up to 2200 m^3/sec, velocities as high as 7.6 m/sec, and transport as much as 98 tons/sec of coarse grained bed load. Some 90 percent of the total sediment load is transported during the rainy season (May-October). Flow is supercritical from the cone to the river mouth. Plane bed and antidunes are the common bed forms. Fluvial deposits are dominantly planar laminated, with some small to large scours. Non-bedded conglomeratic deposits also occur in the fluvial systems.

091-10063-300-00

CHANNEL INCISION CHRONOLOGY AND PALEOHYDRAULICS OF THE DEARBORN RIVER, MONTANA

(*c*) Asst. Professor Michael G. Foley.
(*d*) Field investigation, basic and applied research.
(*e*) The present lower course of the Dearborn River is deeply incised into bedrock, but was apparently established by glacial diversion in very late Pleistocene time. A relict braided outwash channel formerly occupied by the Dearborn River, and now occupied by Flat Creek, an underfit stream, appears to have been a sluiceway at the time of diversion. Thus, if the diversion chronology can be established by detailed mapping and dating procedures, and if paleoflow characteristics can be determined by hydraulic analysis of the abandoned channel, a quantitative rate of bedrock channel incision and adjustment can be determined. Also, the Dearborn River chronology can be used toward the end of establishing an along-river incision chronology for the Missouri River.

091-10064-300-00

INCISION MECHANISM AND HYDRAULICS OF THE SALINE RIVER, ARKANSAS

(*c*) Asst. Professor Michael G. Foley.
(*d*) Field investigation, basic and applied research, Master's thesis.
(*e*) The Saline River displays a bead-on-a-string pattern related to its riffle-and-pool morphology. Reconnaissance indicates that some of the riffle-and-pool morphology is incised in bedrock, and therefore does not indicate direct control by alluvial sediment transport, as does riffle-and-pool morphology of an alluvial stream channel. Field mapping and hydraulic studies will be used to investigate the relation between bedrock channel geometry and alluvial transport processes.

091-10065-820-33

HYDROGEOLOGY AND GEOPHYSICAL DELINEATION OF BURIED GLACIAL RIVER VALLEY AQUIFERS IN NORTHWESTERN MISSOURI

(*b*) Office of Water Research and Technology (U.S.D.I.).
(*c*) Asst. Professors John M. Sharp, Jr. and Russell F. Burmester.
(*d*) Project combines field investigations and applied research. One Master's thesis will be involved.
(*e*) Examine the hydrogeology of buried glacial river valley (or preglacial valley) aquifers; delineate these aquifers; determine their lateral and vertical extent; and to compare geoelectric, gravity, and seismic refraction geophysical methods for groundwater exploration in this particular hydrogeologic setting. We plan to quantitatively estimate: 1) aquifer hydraulic conductivity and storativity, 2) areas of groundwater recharge and discharge, 3) the hydrologic budget, and 4) groundwater salinities. We shall also determine the direction and rates of groundwater flow and the existence of any hydrostratigraphic units. Long-range goals are to determine the aquifer's potential water yield and to provide information for regional planning. A clearly subsidiary objective is to provide data to assist in the reconstruction of Missouri's Pleistocene (Ice-age) history.
(*g*) Results are still inclusive with the exception that gravity profiling has proven an effective tool in reconnaissance of buried valley aquifers.

091-10066-300-33

HYDROGEOLOGIC CHARACTERISTICS OF THE MISSOURI RIVER VALLEY FLOOD PLAIN

(*b*) Office of Water Research and Technology (U.S.D.I.).
(*c*) Asst. Professor John M. Sharp, Jr.
(*d*) Project combines field investigation and application of appropriate digital models. At least one Master's thesis is involved.
(*e*) Examine quantitatively the hydrologic and geologic characteristics of the Missouri River flood plain in a selected area and to determine their effects on groundwater movement, usage, and pollutability. A subsidiary objective is to develop a generalized digital model for groundwater movement in the flood plain. The long-range goal is to employ the above information and model to the selection of utilization criteria for waste disposal and water supply in the Missouri River flood plain.

(*f*) Suspended.

(*g*) Twenty observation wells were installed by a combination of boring and hydraulic jetting. Samples of soils were obtained at each site. These wells have been monitored for changes in water level since August 1975. Maps of the potentiometric surface and soil types were prepared.
A series of finite difference computer models have been developed to simulate observed fluctuations in hydrogeologic conditions. Our conclusions are as follows: 1) The flood plain shows greater hydrogeologic variability than was previously assumed; 2) influence of local streams and springs can lead long-term perturbations in "normal" flood plain hydrogeology; 3) many of the assumptions commonly made in bank storage models are erroneous; 4) flood plain groundwater systems may be separated into local and regional systems; 5) hydraulic jetting of wells has proven to be an economical method for installation of piezometers; 6) the flood plain is a major untapped groundwater resource which will be increasingly developed for supplemental irrigation, industrial, and domestic use; and 7) hydrogeologic information is vital to the proper land use selection in flood plains. Sites most suitable for water supply and waste disposal have been evaluated and criteria established.

(*h*) **Hydrogeology of a Portion of the Missouri River Flood Plain,** N. Grannemann, J. M. Sharp, Jr., *Trans. Mo. Acad. Sci.* **4**, p. 11, 1976.
Hydrogeology of Missouri River Flood Plain, J. M. Sharp, Jr., N. G. Granneman, *Geol. Soc. America, Abs. with Programs, (North-Central Sec.)* **8**, 4, p. 443, 1976.
Application of Missouri River Flood-Plain Hydrogeology in Land Use Planning, *J. Soil Water Conservation* **31**, 2, pp. 73-75, 1976.

UNIVERSITY OF MISSOURI-COLUMBIA, College of Engineering, Department of Mechanical and Aerospace Engineering, Columbia, Mo. 65201. Paul W. Braisted, Department Chairman.

092-09831-050-54

HETEROGENEOUS JET MIXING STUDY USING LASER ANEMOMETER

(*b*) National Science Foundation ENG-74-10074.
(*c*) Dr. John B. Miles, Professor.
(*d*) Experimental; basic research; Master's and Doctoral theses.
(*e*) Investigate both the overall and the detailed nature of the heterogeneous turbulent mixing region formed by the interaction of two parallel streams (one air, the other Freon) initially separated by a thin dividing plate. Instantaneous local velocities are measured (2 components) by a laser anemometer system. Local concentration is measured by an aspirating probe in conjunction with a hot wire anemometer. All data is recorded on an FM tape recorder for subsequent evaluation in terms of power spectrums, time averages, and various correlations.
(*g*) Heterogeneous jet mixing data presently being evaluated.
(*h*) **Similarity Parameter for Two-Stream Turbulent Jet-Mixing Region,** J. B. Miles, J. S. Shih, *AIAA J.* **6**, 7, pp. 1429-1430, 1968.
Two-Stream Heterogeneous Mixing Measurements Using Laser Doppler Velocimeter, J. B. Miles, D. A. Johnson, *AIAA J.* **10**, 10, pp. 1353-1355, 1972.
The Turbulent Heterogeneous Mixing Region, J. L. Brown, *M.S. Thesis*, Univ. of Missouri-Columbia.
J. L. Brown, *Ph.D. Dissertation* (in preparation).

UNIVERSITY OF MISSOURI—ROLLA, School of Engineering, Department of Chemical Engineering, Rolla, Mo. 65401. Dr. J. L. Zakin, Professor.

093-06405-250-00

TURBULENCE INTENSITIES IN DRAG REDUCING ORGANIC SOLUTIONS

(*c*) Dr. J. L. Zakin or Dr. G. K. Patterson.
(*d*) Experimental; basic research.
(*e*) Details of the turbulence structure of drag reducing and non-drag reducing solutions are being investigated. Turbulence intensities, frequency spectra, integral scales and other turbulence quantities are being compared for drag reducing and non-drag reducing solutions.
(*g*) The results of turbulence measurements in solvents using wedge probes closely check the accepted values for measurements in air. A comparison of wedge, parabolic, cone and cylindrical hot-film probes showed the wedge and parabolic probes gave identical results while cone probes gave slightly low intensities. Cylindrical data were erratic because of eddy shedding. In viscoelastic solutions, high and low values of turbulence intensities are observed depending on the flow velocity. The frequency response of hot-film wedge probes was shown to be flat up to 100 cps so that frequency response of the probe cannot account for these discrepancies. Pressure probe intensity results were found to be inaccurate in viscoelastic fluids except at the center line of a tube.
(*h*) **Response of Hot-Film Wedge Probes in Viscoelastic Fluids,** J. M. Rodriguez, G. K. Patterson, J. L. Zakin, *Proc. Symp. on Turbulence Measurements in Liquids*, Univ. of Missouri–Rolla Continuing Education Series, 1971.
Measurement of Turbulence Intensities with Piezoelectric Probes in Viscoelastic Fluids, J. M. Rodriguez, G. K. Patterson, J. L. Zakin, *J. Hydronautics* **5**, p. 101, 1971.
Turbulence Structure in Drag-Reducing Polymer Solutions, accepted by *Phys. Fluids.*
Split-Film Anemometry in a Drag Reducing Solution, J. Chosnek, *Ph.D. Thesis*, Univ. Missouri-Rolla, 1975.

093-06408-120-00

VISCOSITY OF POLYMER SOLUTIONS

(*c*) Dr. K. G. Mayhan.
(*d*) Experimental; basic research.
(*e*) The effects of polymer concentration, molecular weight, solvent-polymer interactions and polymer structure on viscosity are being investigated.
(*g*) Viscosity-concentration data of a number of polymer solutions in "good" solvents fit a single curve when plotted as $\eta_{sp}/C(\eta)$ vs. $k'(\eta)C$ up to the region of incipient molecular overlap. Data on "fair" solvent solutions also fit a single curve. Generalized curves over wider concentration ranges are obtained for η_R vs. $C(\eta)$ data.
(*h*) **Generalized Correlations for Molecular Weight and Concentration Dependence of Zero-Shear Viscosity of High Polymer Solutions,** *J. Poly. Sci. (Poly. Phys. Ed.)*, **14**, p. 299 (1976).

093-07501-130-84

SOLID SUSPENSION DRAG REDUCTION

(*b*) Petroleum Research Fund of the American Chemical Society.
(*c*) Dr. J. L. Zakin or Dr. G. K. Patterson.
(*d*) Experimental, basic research, Ph.D. thesis.
(*e*) An investigation of the particle, fluid and flow variables influencing drag reduction in the flow of solid suspensions.
(*f*) Complete.
(*g*) Drag reduction in solid-liquid systems has been shown to be possible only with fibrous materials, contrary to previous reports in the literature. Increased 4/d and fiber flexibility both enhance drag reduction. Concentration effects are complex. There is a similarity between fiber-liquid drag reduction and particle-gas drag reduction results observed by some authors. The latter may be due to charge

effects in the gas-solid systems and variations in charge effects may account for the variations in pressure drop results from system to system.

(*h*) **Drag Reduction in Solid-Liquid Suspensions in Pipe Flow,** I. Radin, J. L. Zakin, G. K. Patterson, *Nature Phys. Science* **246**, p. 11, 1973.

Drag Reduction in Solid-Fluid Systems, I. Radin, J. L. Zakin, G. K. Patterson, *AIChE J.* **21**, p. 358 (1975).

Solid Fluid Drag Reduction, I. Radin, *Ph.D. Thesis*, Univ. of Missouri-Rolla, 1974.

093-07502-120-00

MEASUREMENT OF COMPLEX MODULUS IN DILUTE POLYMER SOLUTIONS

(*c*) Dr. Gary K. Patterson.
(*d*) Experimental, basic research, Ph.D. thesis.
(*e*) An instrument has been developed which is capable of measuring complex shear modulus at audio frequencies in dilute (below interaction) concentrations. Studies of effect of concentration and molecular weight dispersion on complex modulus are planned. The instrument has been modified to also accommodate soft solid materials so that shear modulus measurements may also be made on them.
(*g*) The instrument has been used for measurements in dilute polymer solutions and greases and seems to perform well, giving data of a reproducible character and similar to accepted literature data on solutions already measured. Preliminary results with soft solids show promise for this application as well.

093-07503-020-00

SEGREGATION INTENSITIES AND REACTION RATES IN A STIRRED-TANK REACTOR

(*b*) National Science Foundation.
(*c*) Dr. Gary K. Patterson.
(*d*) Theoretical, basic research, Ph.D. thesis.
(*e*) Segregation intensity and reaction conversion distributions are being measured and modeled for stirred-tank flow reactors under various conditions.
(*g*) Results of mixing and reaction conversion measurements are compared with the model calculations. Extension of the basic model to transient (unsteady) conditions has been made and a number of model computations for reactor upsets, batch operation, and semi-batch operation have been made. The model is being extended to include mixing effects on polymerization and fermentation reactions.
(*h*) **Segregation Intensity Distribution in Tank Mixer With and Without Second-Order Reaction,** G. K. Patterson, *Proc. Chemeca* **70**, Butterworth's, Sydney, Australia, 1971.

A Fundamental Dynamic Response Model for CSTR's, G. K. Patterson, L. L. Otte, presented at *1st ISA Joint Spring Conf.*, St. Louis, Mo., Apr. 25, 1973.

Model With No Arbitrary Parameters for Mixing Effects on Second-Order Reaction With Unmixed Feed Reactants, G. K. Patterson, *Proc. ASME Mixing Symp.*, Atlanta, Ga., June 22, 1973.

Simulating Turbulent-Field Mixers and Reactors or Taking the Art Out of the Design, G. K. Patterson, presented at *77th Natl. AIChE Mtg.*, Pittsburgh, June 1973, a chapter of *Application of Turbulence Theory to Mixing Operations*, ed. by R. S. Brodkey, Acad. Press, N. Y., in press.

Simulation and Scale-Up of Turbine and Propeller Agitated Vessels, G. K. Patterson, *Proc. BHRA Symp. on Mixing and Separation*, Cambridge, Sept. 1974.

Modell zur Computer-Berechnung des Turbulenten Mischens mit Reaktionen 2. Ordnung, G. K. Patterson, *Chemie-Ingenieur-Technik* **46**, p. 999, 1974.

Turbulence Level Significance of the Monte-Carlo Interaction Parameter, R. M. Canon, A. W. Smith, K. W. Wall, G. K. Patterson, submitted to *Chem. Eng. Sci.*

Average Molecular Weight Distributions in Stirred-Tank Reactors By a Random Coalescence-Dispersion Simulation, G. K. Patterson, presented at *78th Natl. AIChE Mtg.*, Houston, Tex., Mar. 1975.

093-08861-050-15

COHERENCE OF HIGH PRESSURE JETS

(*b*) U.S. Army Mobility Equipment Res. and Dev. Ctr., Fort Belvoir.
(*c*) Dr. J. L. Zakin or Dr. D. A. Summers.
(*d*) Experimental, applied research, M.S. thesis.
(*e*) The effects of pressure, nozzle size, fluid properties and traversing speed on the coherence length of high pressure turbulent liquid jets are being studied. Such jets are useful in cutting, mining, drilling and earth moving.
(*g*) The influence of pressure and nozzle size on jet coherence varies depending on the jet Reynolds number range. The addition of small amounts of certain viscoelastic additives to the liquid greatly increases the coherent length of the jet.
(*h*) **The Effect of Pressure, Jet Diameter and Viscoelastic Additives on High Velocity Jet Structure and Cutting Ability,** D. A. Summers, J. L. Zakin, presented to *67th Ann. AIChE Mtg.*, 1974.

The Effect of Viscoelastic Additives on Jet Structures, J. L. Zakin, D. A. Summers, presented *3rd Jet Cutting Technology Symp.*, Chicago, 1976.

093-10075-370-54

TRANSPORT OF CRUDE OIL AS OIL-IN-WATER EMULSIONS

(*b*) NSF.
(*c*) Dr. J. L. Zakin.
(*d*) Experimental, applied research, M.S. thesis.
(*e*) The use of concentrated oil-in-water emulsions as a technique for transporting high viscosity and/or high pour point curdes is being compared with conventional heating techniques. Experimental results for turbulent flow of concentrated emulsions is being obtained and a feasibility study will be made.
(*g*) The variables of oil concentration, oil viscosity, pumping temperature and tube diameter, were investigated. Attempts to correlate turbulent pressure losses with the Dodge-Metzner correlation showed predicted pressure losses were generally high.
(*h*) **Reduction of Drag in the Turbulent Transport of Solid and Liquid Suspensions in Water,** J. L. Zakin, M. E. Borgmeyer, G. K. Patterson, presented *Intl. Symp. on Freight Pipelines*, Washington, 1976.

Transport of Crude Oil as Oil-In-Water Emulsions, J. L. Zakin, R. Pinaire, M. E. Borgmeyer, presented *ASME Fluids Engrg. Mtg.*, New Haven, 1977.

The Rheology of Oil-In-Water Emulsions, M. E. Borgmeyer, *M.S. Thesis*, Univ. Missouri-Rolla, 1975.

UNIVERSITY OF MISSOURI—ROLLA, Department of Civil Engineering, Rolla, Mo. 65401. Joseph H. Senne, Department Chairman.

094-06287-810-00

MODIFIED STATION-YEAR METHOD FOR FLOOD FREQUENCIES

(*c*) Dr. T. E. Harbaugh.
(*d*) Design.
(*e*) Determination of flood peaks for small drainage areas in Missouri based on physiographic data.

094-07504-200-00

EFFECTS OF RAINDROP IMPACT ON OVERLAND FLOW

(*c*) Dr. G. T. Stevens, Jr.
(*d*) Experimental.
(*e*) Work is being performed in the laboratory to determine the effect of raindrop impact as a contributing factor in the resistance to flow for short overland flow conditions.
(*h*) Ph.D. Dissertation pending.

094-07505-350-88

TIME SEQUENCED DAM FAILURES

(*b*) National Defense Education Act.
(*c*) Dr. T. E. Harbaugh.
(*d*) Experimental.
(*e*) Determination of the influence of a controlled breaking of a dam upon the ensuing downstream flood wave.
(*h*) Ph.D. Dissertation completed.

094-07506-220-33

EVALUATION OF A SINGLE LAYER OF GRADED GRAVEL AS A PROTECTIVE FILTER ON EMBANKMENT SLOPES

(*b*) Office of Water Resources Research.
(*c*) C. D. Muir, Assoc. Professor.
(*d*) Experimental.
(*e*) Determine the effect of thickness and gradation on the ability of a single graded filter layer to prevent the migration of finer particles through the layer.
(*h*) Master's Thesis completed.

094-07507-200-00

A SENSITIVITY ANALYSIS OF THE SPATIALLY VARIED UNSTEADY FLOW EQUATIONS

(*c*) Dr. T. E. Harbaugh.
(*d*) Theoretical.
(*e*) Computer solutions of the spatially varied flow equations are being performed for various boundary, finite difference, mesh sizes, and inputs to determine the sensitivity of the equations to a variety of parameters.
(*h*) Ph.D. Dissertation (G. T. Stevens, Jr.) completed.

094-08862-220-13

VELOCITY DISTRIBUTION VERSUS SEDIMENT IN THE MISSOURI RIVER

(*b*) Dept. of the Army, Kansas City Dist., Corps of Engineers.
(*c*) Dr. G. T. Stevens, Jr.
(*d*) Applied research.
(*e*) An attempt was made to fit experimentally developed sediment transport equations to the Missouri River.
(*f*) Completed.

094-08863-300-13

THE MISSOURI RIVER COMPUTERIZED DATA BANK

(*b*) Dept. of the Army, Kansas City Dist., Corps of Engineers.
(*c*) Dr. G. T. Stevens, Jr.
(*d*) Applied research.
(*e*) Collection and storage of all available velocity and sediment data that is needed in the development of a typical Missouri River velocity and sediment concentration profile. These profiles then can be utilized in a sediment transport relationship for the Missouri River.
(*f*) Completed.

094-08864-810-00

UNIT HYDROGRAPH FOR OZARK SECTION OF SOUTHWEST MISSOURI

(*c*) Dr. G. T. Stevens, Jr.
(*d*) Design.
(*e*) Development of a synthetic unit hydrograph for the Ozark section of Missouri and Arkansas using readily available physiographic data.
(*h*) Master's Thesis completed, Melvin Schaefer.

094-08865-310-00

A MULTIPLE-PLAN EVALUATION MODEL FOR SMALL UNGAGED WATERSHEDS

(*c*) Dr. G. T. Stevens, Jr.
(*d*) Design.
(*e*) A computer model for simulation of the effect of alternative measures for flood damage reduction. The goal is to optimize the value of an objective function which will maximize the amount of net benefits returned by the project.
(*h*) Completed Master's Thesis, J. R. Dexter.

094-08866-810-00

A COMPARISON OF THREE URBAN HYDROLOGY MODELS

(*c*) Dr. G. T. Stevens, Jr.
(*d*) Design, Master's thesis.
(*e*) A comparison of three models used for the calculation of urban stormwater runoff is presented. Simulation results are based on the capability of these models to reproduce observed peak discharges, time to peak and the direct runoff volume.
(*h*) Completed Master's Thesis, R. F. Astrack.

094-08867-810-00

A STATISTICAL HYDROLOGIC SIMULATION MODEL

(*c*) Dr. G. T. Stevens, Jr.
(*d*) Applied research, design.
(*e*) A simulation model for small watersheds using probabilistic models derived from short term rainfall-runoff records are developed. The model is used to generate a synthetic flood series which is compared to the observed flood series.
(*h*) Completed Master's Thesis, R. L. Wycoff.

094-08868-350-00

RESERVOIR DESIGN: SIMULATION TECHNIQUES

(*c*) Dr. G. T. Stevens.
(*d*) Design, applied research.
(*e*) A computerized simulation model using hydrologic routing techniques is developed to aid in the analysis of small dams to reduce the possibility of inadequate spillway design. Simulation equation derived from the continuity equation to describe reservoir storage and outflow. Newton's iteration technique is utilized to solve the simulation equations. The resulting model determines an optimum size auxiliary spillway having a minimum crest length for a range of spillway elevations.
(*h*) Completed Master's Thesis, L. W. Mays.

094-08869-880-13

MISSOURI RIVER ENVIRONMENTAL INVENTORY

(*b*) Dept. of the Army, Kansas City Dist., Corps of Engineers.
(*c*) Dr. P. R. Munger.
(*d*) Field investigation.
(*e*) Study was conducted to obtain baseline information which could be used in preparation of an operation and maintenance environmental impact statement by the Corps. The investigation consisted of a literature review and selected field studies of the aquatic ecosystems and natural resources bordering the river.
(*f*) Completed.

094-08870-880-13

A BASE LINE STUDY OF THE MISSOURI RIVER

(*b*) Dept. of the Army, Kansas City Dist., Corps of Engineers.
(*c*) Dr. P. R. Munger.
(*d*) Field investigation.
(*e*) To increase the understanding of the interrelationships which exist between the activities conducted by the Corps of Engineers in, on, and in the vicinity of, the Missouri River and the environment of the region traversed.
(*f*) Completed.

094-08871-870-00

ENVIRONMENTAL INVENTORY AND ASSESSMENT OF AREAS I, II, III, AND IV, ARKANSAS RIVER CHLORINE CONTROL PROJECT, OKLAHOMA AND KANSAS

(*c*) Dr. Ju-Chang Huang.
(*d*) Field investigation.

(*e*) Collect background information of environmental resources, including geological feature, hydraulic and hydrological characteristics, water quality, socio-economical conditions, aquatic and terrestrial biology, etc., of the four study areas associated with the Arkansas River Chloride Control Project. Assessments of potential environment impacts which will be incurred as a result of the chloride control project implementation will be made in this investigation.

094-10011-300-13

LOWER MISSISSIPPI VALLEY DISTRICT POTAMOLOGY STUDY (T-1)

(*b*) Department of the Army, St. Louis District, Corps of Engineers.
(*c*) Paul R. Munger.
(*d*) Field investigation and applied research.
(*e*) To compile available data on revetments and dikes, geology and hydrology, morphology, and levees, over a large reach of the Mississippi River. To indicate, where possible, relationships between the changes that have taken place in the river over time and the above factors. To inspect field information and to indicate insufficiencies and data gaps that presently exist.
(*f*) Completed.

094-10012-300-13

LOWER MISSISSIPPI VALLEY DISTRICT POTAMOLOGY STUDY (S-7)

(*b*) Department of the Army, St. Louis District, Corps of Engineers.
(*c*) Jerome A. Westphal.
(*d*) Field investigation and applied research.
(*e*) To document changes which occurred in the Middle Mississippi River along with the associated human activity which influenced changes. River elements were examined for changes in top-bank width, cross sectional area at selected locations, invert profile, and river length along the thalweg. Human activities were examined in conjunction with changes in river channel elements. These included construction of dikes, levees, revetments, and bank clearing. All comparisons and anaysis reflected conditions from the earliest recorded description through 1974.

094-10013-700-13

ST. LOUIS DISTRICT POTAMOLOGY STUDY (S-3)

(*b*) Department of the Army, St. Louis District, Corps of Engineers.
(*c*) Glendon T. Stevens, Jr.
(*d*) Field investigation and applied research.
(*e*) Comparison of velocity measuring equipment and discharge calculating techniques; to determine if there is a difference between present day and those previously used techniques.

MONTANA STATE UNIVERSITY, Department of Agricultural Engineering, Agricultural Experiment Station, Bozeman, Mont. 59715. Professor William E. Larsen, Department Head.

095-08161-840-31

SURFACE IRRIGATION HYDRAULICS

(*b*) U.S. Bureau of Reclamation.
(*c*) Professor C. C. Bowman.
(*d*) Research is based on theoretical and field investigations. The theoretical phase has been completed and it is now being applied to field conditions.
(*e*) Theoretical equations were developed for computing the flows required to give efficient application of water by surface flow systems. Curves were developed for design and management tools. Complete automation is being studied with the development of a soil moisture monitoring system to activate full radio controls.
(*g*) An electronic soil moisture monitor has been developed which warns of plant stress before it is visible to the operator, thus allowing irrigation at the proper time for optimum production.

MONTANA STATE UNIVERSITY, Department of Civil Engineering and Engineering Mechanics, College of Engineering, Bozeman, Mont. 59715. Dr. William A. Hunt, Acting Department Head.

096-07513-260-06

PIPELINE TRANSPORT OF WOODCHIP AND WATER MIXTURES

(*b*) U.S. Dept. of Agriculture, Forest Service.
(*c*) Dr. W. A. Hunt.
(*d*) Theoretical and experimental studies of applied research on 2000-ft test loop of 8-in. dia. pilot line.
(*e*) Obtain head loss correlations for mixtures of woodchips and water in pipelines; development of mechanical injection system for woodchips; preliminary analysis of corrosion effects of mixtures of water and woodchips on steel pipes; operation of remote pump in by-pass line; compilation of data for design and operation of woodchip pipelines.
(*f*) Studies and report completed.
(*g*) A correlation for calculating the Weisbach friction factor, f, for mixtures of wood chips in water is presented. The correlation, based on concentration of wood chips, pipe diameter, size of wood chips, kinematic viscosity of water and gravitational acceleration, was determined from analysis of 922 data points observed in tests conducted on 3-, 4-, 6-, 8-, and 12-inch-diameter pipelines. Preliminary studies of corrosion studies were initiated; operational problems of pipelines are discussed with strip chart data of conditions prior to intentional line plugging shown.
(*h*) Final report due in July, 1977.

096-08162-800-61

OPERATIONS MODEL FOR MONTANA'S WATER RESOURCES

(*b*) Montana University Joint Water Resources Research Center.
(*c*) Theodore T. Williams, Professor.
(*d*) Theoretical study of an applied research project for a Ph.D. degree.
(*e*) See WRRC **8**, 6.0823.
(*f*) Completed.
(*h*) **Sequential Optimization of Multiple Non-Monetary Objectives in the Operation of Reservoir Systems,** G. V. V. Rao, *Ph.D. Thesis*, Montana State Univ., 1974. Final Report pending.

096-08872-820-61

IMPACT OF LAND USE CHANGE ON THE GROUNDWATER RESOURCES OF THE BOZEMAN, MONTANA AREA

(*b*) Montana University Joint Water Resources Research Center.
(*c*) Dr. R. L. Brustkern.
(*d*) Theoretical study of an applied research project for a M.S. degree.
(*e*) Impact of land use changes in an area of rapid devlopment around Bozeman, Montana, are under study. A groundwater model using finite difference techniques is being developed to investigate the effects of projected land use changes on the groundwater flows.
(*f*) Final report being written.

096-10615-870-36

A COOPERATIVE PROGRAM TO EVALUATE SURFACE AND GROUNDWATER PROBLEMS ASSOCIATED WITH POTENTIAL STRIP MINE SITES

(*b*) EPA–Mining Pollution Control Branch.
(*c*) Professor Theodore T. Williams.
(*d*) Field investigation of an applied research problem.
(*e*) The impact of strip mining on the surface and groundwater systems is being investigated. Field sites in three states (Montana, Wyoming, and North Dakota) are being monitored. Models of the hydrologic systems are being developed.

096-10616-370-36

CONTAMINATION OF TRANSPORT WATER IN COAL-SLURRY PIPELINES

(*b*) U.S. Environmental Protection Agency.
(*c*) Dr. Howard S. Peavy.
(*d*) Experimental studies of applied research.
(*e*) A slurry of 50 percent water, 50 percent coal (by weight) is to be pumped in an 8-inch 240-foot, closed-loop pipeline for an extended period of time. Primary purpose is to determine contamination of transport water by elements in the coal and to determine possible treatment techniques at the pipeline discharge point. Hydraulic data will also be recorded.
(*h*) Final report due July 1978.

096-10617-870-36

THE EFFECTS OF SEPTIC TANK DRAINFIELD ON WATER QUALITY IN AREAS OF HIGH GROUNDWATER

(*b*) U.S. EPA (through the local Areawide Planning Organization).
(*c*) Dr. Howard S. Peavy.
(*d*) Field investigation, applied research.
(*e*) Wells have been sunk around septic tank drainfields located in high groundwater. The movement of contaminants from the drainfield through the groundwater flow is being monitored.
(*h*) Final report due Sept. 1, 1977.

UNIVERSITY OF NEBRASKA-LINCOLN, Department of Mechanical Engineering, Lincoln, Nebr. 68588. Alexander R. Peters, Chairman.

097-09833-010-00

TRANSIENT BOUNDARY LAYER IN CHANNELS WITH SUCTION-BLOWING

(*c*) Professor Pau-Chang Lu.
(*d*) Theoretical; basic; M.S. thesis.
(*e*) Analysis is made of a transient, fully developed, laminar flow of an incompressible fluid in a porous, parallel-plate channel. The crossflow through the plates is uniform, but is allowed to vary with time. In addition to a pressure gradient due to pumping, the flow is also under the inducement of the motion of one of the plates. Numerical results are obtained through the (final or nonfinal) use of the finite Fourier sine transform. Asymptotic flow patterns showing transient boundary layers are investigated. Finally, the formation of the flow from the start is described in physical terms.
(*f*) Completed.
(*h*) **Transient Boundary Layers between Porous Plates,** W. A. Fiveland, P.-C. Lu, *J.A.M.* **98,** pp. 555-558, 1976.

097-09834-110-00

FLOW OF ELECTRICALLY CONDUCTING LIQUIDS IN DUCTS

(*c*) Professor Pau-Chang Lu.
(*d*) Theoretical; basic; Ph.D. thesis.
(*e*) It is demonstrated numerically that regions of backflow do exist in steady, fully-developed, laminar magnetohydrodynamic flows inside straight, insulating ducts of circular sectorial cross sections when the applied field generated by a current through a wire (parallel to the flow and concentric with the two cylindrical walls) is strong enough. This phenomenon of backflow seems to be more prominent as the sectorial angle of the duct increases. When it does appear, it tends to be located near the walls, thus destroying the boundary layer structure usually associated with magnetohydrodynamic duct flows at large Hartmann numbers. A physical explanation based on sketched configurations of the induced current is offered in support of the numerical results.
(*f*) Completed.
(*h*) **A Magnetohydrodynamic Problem with Backflow in Ducts of Sectorial Cross Sections,** P.-C. Lu, H. S. Izawa, *Dev. in Th. App. Mech.* **8,** pp. 565-574, 1976.

UNIVERSITY OF NEW ORLEANS, School of Engineering, New Orleans, La. 70122. Dr. E. P. Russo, Professor of Mechanical Engineering.

098-09996-330-10

FLOW OF POLLUTANTS THROUGH A LOCK

(*b*) U.S. Corps of Engineers.
(*d*) Field investigations; design.
(*e*) The project studies the flow of pollutants through a lock in order to provide a basis for estimating their effects.
(*f*) Inactive.
(*h*) **Flow of Pollutants through a Lock,** *Proc. ASCE* **102,** WW2, May 1976.

098-09997-220-10

FLOW-SEDIMENTATION MODEL

(*b*) U.S. Corps of Engineers.
(*d*) Theoretical; design.
(*e*) An easily applicable method of computing sediment transport, including determination of areas of scour and deposition, is presented.
(*h*) **Application of Flow-Sediment Model to Red River,** *ASCE J. Hydr. Div.*, pp. 11-18, Jan. 1977.

NEW MEXICO INSTITUTE OF MINING AND TECHNOLOGY, Socorro, N.M. 87801. Dr. Vijay P. Singh.

099-09847-810-33

A SYSTEMATIC INVESTIGATION OF WATERSHED RUNOFF

(*b*) Office of Water Research and Technology.
(*d*) Theoretical and applied.
(*e*) Develop a systematic approach based on kinematic wave theory to investigate watershed runoff and compare it with existing approaches.
(*g*) Kinematic wave models have been developed to study watershed surface runoff. A comparison of models has been made to develop objective criteria for their selection. To all watershed models precipitation forms input. An investigation of this input was carried out.
(*h*) **Studies on Rainfall-Runoff Modeling: 1. Estimation of Mean Areal Rainfall,** V. P. Singh, Y. K. Birsoy, *WRRI Rept. 061*, N. Mex. Water Resources Res. Inst., N. Mex. State Univ., Las Cruces, N. Mex., 70 pages, 1975.
Comparison of the Methods of Estimating Mean Areal Rainfall, V. P. Singh, Y. K. Birsoy, *Nordic Hydrology* **6,** 4, pp. 222-241, 1975.
A Rapid Method of Estimating Mean Areal Rainfall, V. P. Singh, *Water Resources Bulletin* **12,** 2, pp. 307-315, 1976.
Studies on Rainfall-Runoff Modeling: 2. A Distributed Kinematic Wave Model of Watershed Surface Runoff, V. P.

Singh, *WRRI Rept. 065*, N. Mex. Water Resources Res. Inst., N. Mex. State Univ., Las Cruces, N. Mex., 154 pages, 1976.
Studies on Rainfall-Runoff Modeling: 3. Converging Overland Flow, V. P. Singh, *WRRI Rept. 073*, N. Mex. Water Resources Res. Inst., N. Mex. State Univ., Las Cruces, N. Mex., 290 pages, 1976.
Studies on Rainfall-Runoff Modeling: 4. Estimation of Parameters of Two Mathematic Models of Surface Runoff, K. V. Shelburne, V. P. Singh, *WRRI Rept. 076*, N. Mex. Water Resources Res. Inst., N. Mex. State Univ., Las Cruces, N. Mex., 96 pages, 1976.
Studies on Rainfall-Runoff Modeling: 5. A Uniformly Nonlinear Hydrologic Cascade, V. P. Singh, *WRRI Rept. 078*, N. Mex. Water Resources Res. Inst., N. Mex. State Univ., Las Cruces, N. Mex., 47 pages, 1976.
Studies on Rainfall-Runoff: 6. A Statistical Analysis of Rainfall-Runoff Relationships, V. P. Singh, Y. K. Birsoy, *WRRI Rept. 081*, N. Mex. Water Resources Res. Inst., N. Mex. State Univ., Las Cruces, N. Mex., 47 pages, 1976.
Derivation of Surface Water Lag Time for Converging Overland Flow, V. P. Singh, *Water Resources Bulletin* **11,** 6, pp. 1091-1102, 1975.
Hybrid Formulation of Kinematic Wave Models of Watershed Runoff, V. P. Singh, *J. Hydrology* **27,** pp. 33-50, 1975.
A Distributed Approach to Kinematic Wave Modeling of Watershed Run-off, V. P. Singh, *Proc. Natl. Symp. Urban Hydrology and Sediment Control*, pp. 227-236, Lexington, Ky., 1975.
Derivation of Time of Concentration, V. P. Singh, *J. Hydrology* **30,** pp. 147-166, 1976.
A Note on the Step Error of Some Finite Difference Schemes Used to Solve Kinematic Wave Equations, V. P. Singh, *J. Hydrology* **30,** pp. 247-255, 1976.
Comparison of Two Mathematical Models of Surface Runoff, V. P. Singh, *IAHS Bulletin* **21,** 2, pp. 285-299, 1976.
A Distributed Converging Overland Flow Model: 1. Mathematical Solutions, B. Sherman, V. P. Singh, *Water Resources Research* **12,** 6, pp. 889-896, 1976.
A Distributed Converging Overland Flow Model: 2. Effect of Infiltration, B. Sherman, V. P. Singh, *Water Resources Research* **12,** 6, pp. 897-901, 1976.
A Distributed Converging Overland Flow Model: 3. Application to Natural Watersheds, V. P. Singh, *Water Resources Research* **12,** 6, pp. 902-908, 1976.
Mathematical Aspects of Surface Runoff, V. P. Singh, *Proc. ASCE Symp. Inland Waterways for Navigation, Flood Control and Water Diversions*, Fort Collins, Colo., pp. 773-792, 1976.

NEW YORK OCEAN SCIENCE LABORATORY of Affiliated Colleges and Universities, Incorporated, Box 867, Edgemere Road, Montauk, N.Y. 11954. John C. Baiardi, President and Director.

100-10071-450-00

NUMERICAL MODELING OF THE CIRCULATION AND TRANSPORT OF BLOCK ISLAND SOUND AND ADJACENT WATERS

(*c*) Dr. Rudolph Hollman.
(*d*) Experimental, applied research.
(*e*) A two-dimensional time dependent model is being applied to Block Island Sound and parts of the Peconic Bay System using environmental data as inputs.
(*g*) The model is currently being updated and applied to these waters.
(*h*) **Environmental Atlas of Block Island and Eastern Long Island Sound Waters, Vol. 1: Description of the Programs Associated with the Data Base and Listing on Micro-Fiche,** *NYOSL Tech. Rept. No. 0034*, 32 pages.
Vol. 2: Physical and Chemical Database at Observed and Standard Depths: 1970 through 1973, *NYOSL Tech. Rept. No. 0035*, 419 pages, 875 Station Entries.
Vol. 3: A Histogram Analysis of the Annual Variations of Physical and Chemical Parameters: 1970 through 1973, *NYOSL Tech. Rept. No. 0036*, 401 pages.

POLYTECHNIC INSTITUTE OF NEW YORK, Aerodynamics Laboratories, Route 110, Farmingdale, N.Y. 11735. Professor M. H. Bloom, Director.

101-09893-740-50

COMPUTATIONAL FLUID DYNAMICS

(*b*) National Aeronautics and Space Administration, Air Force Office of Scientific Research.
(*c*) Professor Stanley G. Rubin.
(*d*) Basic theoretical research; Masters theses.
(*e*) In order to increase computational efficiency for viscous flow calculations, higher-order polynomial (spline) methods have been applied to laminar and turbulent boundary layer flows, as well as the incompressible Navier-Stokes equations. The laminar flow in a rectangular inlet has been critically examined in order to accurately determine the secondary motion and demonstrate a predicted Reynolds number independence principle. The strong effect of turbulent stresses on the secondary motion near an axial corner flow has been examined in order to more clearly understand the nature of turbulent corner flow interactions.
(*h*) **Numerical Methods Based on Polynomial Spline Interpolation,** S. G. Rubin, P. K. Khosla, *Proc. 5th Intl. Conf. Numerical Methods in Fluid Dynamics (Lecture Notes in Physics 59)*, Springer-Verlag, Heidelberg, 1976.
Laminar Flow in Rectangular Channels. Part I–Entry Analysis. Part II–Numerical Solution for a Square Channel, S. G. Rubin, P. K. Khosla, S. Saari, *Proc. ASME Symp. Numerical/Laboratory Computer Methods in Fluid Mechanics*, N.Y., Dec. 1976.
Higher-Order Numerical Methods Derived From Three-Point Polynomial Interpolation, S. G. Rubin, P. K. Khosla, *NASA CR-2735*, Aug. 1976.
The Turbulent Boundary Layer Near a Corner, M. Shafir, S. G. Rubin, *J. Appl. Mech.* **43,** Series E, 4, Dec. 1976.

101-09894-630-52

VORTEX AUGMENTOR CONCEPT FOR WIND ENERGY CONVERSION

(*b*) Energy Research and Development Administration.
(*c*) Professor P. M. Sforza.
(*d*) Experimental, theoretical, and field investigation, applied research and design.
(*e*) Research design, and development on aerodynamic devices which can concentrate and augment natural winds is being performed. The keystone element is the generation and control of discrete vortices of high power density by the appropriate interaction of suitably designed aerodynamic surfaces with natural winds of low power density. Properly configured turbines are utilized to transform the energy in this compacted vortex field to useful shaft work. This idea is termed the Vortex Augmentor Concept (VAC, patent pending).
(*g*) The concept has been reduced to practice in wind tunnel tests. Flow measurements in vortex fields and theoretical calculations indicate power augmentation factors of 2 to 9 over conventional turbines for a given rotor diameter. An outdoor wind characteristics facility has been constructed in which field tests of large scale prototypes are carried out. Computer acquisition and processing of performance data are used.
(*h*) **Vortex Augmentors for Wind Energy Conversion,** P. M. Sforza, *Proc. Intl. Symp. Wind Energy Systems, BHRA Fluid Engrg.*, Cambridge Univ., England, Sept. 7-9, 1976 (to be published Apr. 1977).

Flow Measurements in Leading Edge Vortices, P. M. Sforza, et al., *AIAA Paper No. 77-11, 15th AIAA Aerospace Sciences Mtg.*, Los Angeles, Calif., Jan. 1977.

101-09895-700-50

LASER DIAGNOSTICS

(*b*) National Aeronautics and Space Administration, Office of Naval Research, National Science Foundation.
(*c*) Professor S. Lederman.
(*d*) Basic experimental research, Masters and Ph.D. theses.
(*e*) The development of nonintrusive diagnostic techniques in flow fields is the aim of this work. The techniques investigated are the spontaneous Raman diagnostics for concentration and temperature measurements, Laser Doppler Anemometry for velocity and turbulence measurements, Brillouin scattering for flow field fluctuation measurements, and Coherent Anti-Stokes Raman Scattering for concentration and temperature measurements in situations where the spontaneous Raman may not be applicable. The aforementioned diagnostic techniques are applied to coaxial turbulent jets, flames and combustion, both high and low pressure.
(*h*) **Some Applications of Laser Diagnostics to Fluid Dynamics**, S. Lederman, *AIAA Paper 76-21, AIAA 14th Aerospace Sciences Mtg.*, Washinton, D.C., Jan. 1976.
Modern Diagnostics of Combustion, S. Lederman, *AIAA Paper 76-26, AIAA 14th Aerospace Sciences Mtg.*, Washington, D.C., Jan. 1976.
Experimental Techniques Applicable to Turbulent Flows, S. Lederman, *AIAA Paper 77-213, AIAA 15th Aerospace Sciences Mtg.*, Los Angeles, Calif., Jan. 1977.

101-09896-720-60

STRATIFIED FLOW AND RELATED ENVIRONMENTAL WIND-TUNNEL FACILITIES

(*b*) New York State Science and Technology Foundation, Advance Research Projects Agency, New York City Fire Department.
(*c*) Professor. M. H. Bloom.
(*d*) Experimental research of basic and applied nature.
(*e*) Development and calibration of a thermally stratified wind-tunnel of 4 × 5 ft cross-section to provide simulation of atmospheric boundary layers and of the ocean thermocline. In the unstratified mode the wind-tunnel serves as a conventional low-speed facility. Research involved turbulent wake behavior in stratified ocean regions, flow around urban building systems relevant to internal fume control within high-rise buildings, and internal flows in high rise buildings for fire control.
(*h*) **Wind Tunnel Experiments on Wakes in Stratified Flow Including Criteria and Development of Experimental Equipment**, G. H. Strom, *POLY-AE/AM Rept. No. 76-11*, June 1976.
Fire Safety Design for Buildings, R. J. Cresci, *Proc. 2nd Conf. Designing Buildings for Environmental Protection*, Rutgers Univ., N.J., Apr. 1975.

101-09897-010-50

WING-BODY AERODYNAMICS

(*b*) National Aeronautics and Space Administration, Air Force Office of Scientific Research.
(*c*) Professor S. G. Rubin or Professor A. R. Krenkel.
(*d*) Basic and applied theoretical and experimental research; Masters thesis projects.
(*e*) Boundary layer interactions and secondary motion due to wing-tail assemblies have been examined with a viscous slender body theory. Effects of different geometries and small incidence angles are considered in order to predict possible separation and vortex phenomena near edges and corners. Wing-body interference effects are evaluated by vortex lattice techniques. Large angles of attack are to be considered by using a modified finite-step method. Span loadings are to be evaluated at subsonic speeds. The effects of high lift devices, rotary motion, interference and multipanel wings are under investigation.
(*h*) **Boundary Layer Induced Crossflow Due to Wing-Body Interference**, J. M. Lyons, *Master's Thesis*, June 1976.
The Boundary Layer on a Finite Width Flat Plate, M. E. Mandel, *Master's Thesis*, June 1976.

POLYTECHNIC INSTITUTE OF NEW YORK, Department of Civil Engineering, 333 Jay Street, Brooklyn, N. Y. 11201. Henry F. Soehngen, Department Head.

102-08873-300-00

STREAMFLOW ROUTING UNDER LOW FLOW CONDITIONS

(*c*) Dr. Alvin S. Goodman, Professor.
(*d*) Theoretical, applied research; Doctoral thesis.
(*e*) Develop a computational method to estimate flow characteristics such as stage, velocity and discharge at any stream section, given values of these variables at an upstream location. Low flow conditions are assumed with unsteady, spatially varied flow. Surface runoff from rainstorms and snowmelt are not operative, and groundwater distributions and local interflows are basic variables affecting streamflow.
(*f*) Doctoral thesis completed, May 1975.
(*g*) One-dimensional, non-linear, partial differential equations of motion and continuity were derived for a channel with arbitrary cross-section and flows along the channel were solved by an implicit finite difference numerical technique. Starting with known initial flow conditions and an upstream hydrograph, a Taylor's expansion was used to approximate a trial value of flow depth downstream, and a hydrograph at a downstream point was derived.

102-09947-820-80

EMERGENCY WATER SUPPLIES FOR GROUNDWATER IN HUMID REGIONS

(*b*) Partial support by Engineering Foundation.
(*c*) Dr. Alvin S. Goodman, Professor.
(*d*) Theoretical, applied research; Doctoral thesis, Engineer's report and Project report.
(*e*) Determination of feasibility and potential of a scheme for obtaining emergency water supplies from groundwater in humid regions such as northeastern United States. Water balance and hydraulic model approaches are used to define conditions during periods of pumping and periods when groundwater storage is replenished by natural or artificial recharge.
(*g*) Doctoral thesis completed January 1977 on the development and testing of mathematical model. Work is continuing on model testing and on other aspects related to feasibility of application.
(*h*) Copy of thesis will be available through University Microfilms.

102-09948-870-60

CORRELATION OF MATHEMATICAL MODELS FOR WATER TEMPERATURE WITH AERIAL INFRARED WATER TEMPERATURE SURVEYS

(*b*) New York State Energy Research and Development Authority.
(*c*) Dr. Alvin S. Goodman, Professor.
(*d*) Theoretical, applied research.
(*e*) Development of phenomenological and analytic hydrothermal models to predict subsurface temperatures from surface isothermal maps obtained from infrared overflight scans, to extend the utility of remote sensing.
(*g*) Phase I focusing on phenomenological model has been completed; for four lake discharges, the model predicted subsurface temperatures to a depth of 10 feet with an accuracy of 0.5 °C. Phase II work is continuing.
(*h*) Phase I report is available through P.I.N.Y. N.Y.S. ERDA.

102-09949-340-60

CONCEPTUAL REVIEW AND PRELIMINARY DESIGN OF MULTIFARIOUS WATER INTAKE STRUCTURE

(*b*) New York State Energy Research and Development Authority.
(*c*) Dr. Alvin S. Goodman, Professor.
(*d*) Theoretical, applied research and design.
(*e*) Review of intake structure for thermal power plant, previously developed conceptually to improve biological performance. Analysis and design for feasibility from operational and other engineering standpoints. Recommendations to be made to confirm design which may include physical model and/or prototype testing, in situ field studies, and other investigations.

102-09950-810-00

PREDICTION OF FLOOD DISCHARGES FROM WETLANDS

(*c*) Dr. Alvin S. Goodman, Professor.
(*d*) Theoretical, applied research; for Doctoral thesis.
(*e*) Formulation and testing of a mathematical model using correlation techniques, to predict flood discharges from wetland areas, considering effects of future land development.

STATE UNIVERSITY OF NEW YORK AT BUFFALO, Department of Civil Engineering, Buffalo, N.Y. 14214. Professor Dale D. Meredith, Acting Department Chairman.

103-09966-410-44

PHYSICAL AND ECONOMIC STATUS OF STRAWBERRY ISLAND

(*b*) Sea Grant Program, NOAA, Dept. of Commerce.
(*d*) Field investigation, applied research, Masters thesis.
(*e*) Determine if protective measures are necessary to preserve Strawberry Island from loss by erosive activity and to examine various alternative protective devices as to their effectiveness and cost.

103-09967-420-44

EFFECT OF AN OFFSHORE BARRIER UPON THE WAVE-HEIGHT DISTRIBUTION IN A HARBOR

(*b*) Sea Grant Program, NOAA, Dept. of Commerce.
(*c*) Dr. Volker W. Harms, Asst. Professor.
(*d*) Theoretical, applied research, Masters thesis.
(*e*) The boundary value problem associated with the diffraction of water waves will be solved by a technique based upon the method of Green Functions that is applicable to cylindrical structures of arbitrary cross-sectional geometry.

103-09968-860-33

OPTIMAL OPERATION RULES FOR MULTI-RESERVOIR WATER RESOURCES SYSTEMS

(*b*) Office Water Research and Technology, Dept. of the Interior.
(*d*) Theoretical, applied research.
(*e*) To formulate, refine, and demonstrate methodologies for determining optimal operation rules for multiple purpose, multireservoir systems with stochastic inflows.

103-09969-440-44

OPERATING RULES FOR REGULATION OF GREAT LAKES WATER LEVELS

(*b*) Sea Grant Program, NOAA, Dept. of Commerce.
(*d*) Theoretical, applied research.
(*e*) Develop a methodology for determining optimal regulation rules for Lake Ontario.

103-09970-410-44

HYDRAULIC AND SEDIMENTATION ANALYSIS OF SALMON RIVER INLET

(*b*) Sea Grant Program, NOAA, Dept. of Commerce.
(*d*) Theoretical with field investigation, applied research.
(*e*) To ascertain the relative importance of river flows, waves, and longshore currents in determining the sediment budget and morphology of the spit, inlet and lower Salmon River channel.

103-09971-860-33

CHLORIDE MANAGEMENT IN LAKE ERIE BASIN

(*b*) OWRT, Dept. of the Interior.
(*d*) Theoretical, applied research.
(*e*) The effects of selected salt management programs on future chloride levels in Lake Erie are examined. Also a simulation model for evaluating effects of deicing salt is developed and applied to a case study.
(*f*) Completed.
(*g*) The use of deicing salt is at least twice as much as can be economically justified.
(*h*) **Runoff of Deicing Salt in Buffalo,** New York, R. Rumer, R. Apmann, C. Chien, *4th Symp. on Salt* **1**, The Northern Ohio Geological Soc., Cleveland, Ohio, pp. 407-411, 1973.
Chloride Build-Up and Control in Lake Erie, C. C. Chien, *Ph.D. Thesis*, Dept. Civil Engrg., State Univ. N.Y. at Buffalo, 1974.
Chloride Build-Up and Control in Lake Erie, R. R. Rumer, D. D. Meredith, C. C. Chien, *Proc. 17th Conf. Great Lakes Res.*, Intl. Assoc. Great Lakes Res., pp. 520-534, 1974.
Chlorides in Lake Erie Basin, D. D. Meredith, R. R. Rumer, C. C. Chien, R. P. Apmann, *Water Resources and Environmental Engrg. Res. Rept. No. 74-1*, Dept. Civil Engrg., State Univ. N.Y. at Buffalo, 82 pages, 1974.
Chloride Management in Lake Erie Basin, D. C. Meredith, R. R. Rumer, *Water Resources and Environmental Engrg. Res. Rept. No. 76-2*, Dept. Civil Engrg., State Univ. N.Y. at Buffalo, 65 pages, 1976.

103-09972-440-13

HYDRAULIC MODEL STUDY OF LAKE ERIE

(*b*) U.S. Army Corps of Engineers, Buffalo District.
(*c*) Dr. Kenneth M. Kiser, Assoc. Professor.
(*d*) Experimental and theoretical, applied research.
(*f*) Completed.
(*g*) A physical model of Lake Erie has been constructed with a horizontal scale ratio of 1:100,000 and a vertical scale ratio of 1:250. The model was operated according to Froude law similitude requirements and rotated to incorporate the effect of the earth's rotation. The experimental testing program included studies of the circulation with and without a prevailing wind, studies of the flushing characteristics of the model lake and studies of the fate of selected tributaries including the Detroit River. Comparison of experimentally observed circulation patterns has been made with computed currents using a numerical model adapted and applied specifically to the distorted geometry of the physical model basin. Reactor-type mixing models were formulated and calibrated for the western basin of the physical model. Frictional calibration of the model was accomplished through analysis of the decay of seiche motion.
(*h*) **Hydraulic Model Study of Lake Erie,** R. R. Rumer, K. M. Kiser, A. Wake, K-H. Yu, *Water Resources and Environmental Engrg. Res. Rept. No. 76-1*, Dept. Civil Engrg., State Univ. N.Y. at Buffalo, 117 pages, 1976.

STATE UNIVERSITY OF NEW YORK AT BUFFALO, Department of Engineering Science, Aerospace Engineering and

Nuclear Engineering, Buffalo, N. Y. 14214. Dr. Richard P. Shaw, Professor.

104-08171-470-00

HARBOR RESONANCE

(*d*) Theoretical, basic research.
(*e*) Analytical/numerical studies of resonance of harbors and long waves.
(*g*) Review Article. Numerical Study of Variable Depth Harbors using Finite Element-Boundary Integral Equation Methods.
(*h*) **Forced Long Period Harbor Oscillations,** R. P. Shaw, *Topics in Ocean Engineering III*, Ed. C. Bretschneider, Gulf Publishing Co., 1976.
FEBIE–A Combined Finite Element–Boundary Integral Equation Approach, R. P. Shaw, W. Falby, *Intl. Symp. Innovative Num. Analysis in Eng. Science*, Paris, May 1977.

104-10023-420-00

WATER WAVES

(*d*) Theoretical, basic research.
(*e*) Effects of variable topography on water wave scattering.
(*g*) Several papers published on scattering by island; harbor resonance; scattering by continental slope.
(*h*) **Time Harmonic Scattering by Obstacles Surrounded by an Inhomogeneous Medium,** R. P. Shaw (presented 87th Acoustical Soc. Amer. Mtg., N.Y.C., Apr. 1974), *J. Acoust. Soc. Amer.* **56,** 5, pp. 1354-1360, Nov. 1974.
An Outer Boundary Integral Equation Applied to Transient Wave Scattering in an Inhomogeneous Medium, R. P. Shaw (presented JSME/ASME Applied Mechanics Mtg., Honolulu, Hawaii, Mar. 1975), *J. Appl. Mech.* **42,** 1, pp. 147-152, Mar. 1975.
Boundary Integral Equation Methods Applied to Water Waves, R. P. Shaw, *Boundary Integral Equation Method AMD-11*, ASME, N.Y.C., pp. 7-14, 1975.
Tsunami Scattering by an Island Surrounded by Water of Variable Depth, R. P. Shaw (presented IUGG Tsunami Symp., Wellington, New Zealand, Jan. 1974), *Proc. Intl. Union of Geodesy and Geophysics, Bull. 15*, pp. 133-140, Royal Soc. N.Z., 1976.
FEBIE–A Combined Finite Element–Boundary Integral Equation Approach, R. P. Shaw, W. Falby.
Long Waves Obliquely Incident on a Continental Slope and Shelf with a Partially Reflecting Coastline, R. P. Shaw, presented *IUGG Tsunami Symp.*, Ensenada, Mex., Mar. 1977 (in press).

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STATE UNIVERSITY OF NEW YORK AT BUFFALO, Department of Mechanical Engineering, Buffalo, N.Y. 14214. Benjamin Gebhart, Department Chairman.

105-10117-140-54

CONVECTIVE CIRCULATIONS AND HEAT TRANSFER IN COLD PURE AND SALINE WATER

(*b*) National Science Foundation.
(*c*) B. Gebhart, Professor; J. C. Mollendorf, Asst. Professor.
(*d*) Theoretical and experimental; fundamental research; M.S. and Ph.D. thesis.
(*e*) A new, simple and accurate equation-of-state has been developed for pure and saline water. Effects of density extrema on flow and transport are being investigated for several buoyancy-induced flows.
(*g*) An equation has been developed for the density of pure and saline water. It contains only one term in temperature, as an expansion around the temperature at the density extremum. The salinity and pressure effects appear in the equation in an ordered way. The density variation is fitted in the temperature, salinity and pressure ranges to 20 °C, 40 °/oo and 100 bars abs. The most accurate form is in agreement with the pure water correlation of Fine and Millero, (1973) Journal of Chemical Physics, 59, 5529-5536, to an rms difference of 3.5 ppm. For saline water it agrees to 10.4 ppm with the data of Chen and Millero (1976), Deep-Sea Research, 23, 595-612. The overall rms difference, for both pure and saline water, is 9.0 ppm. Inferences concerning the inherent accuracy of the data arise from the comparisons. Our results also suggest the pressure effect on the extremum temperature, for both pure and saline water. The equation is also separately fitted to the 1-atm correlation of Fofonoff and Bryden (1975), Journal of Marine Research, 33, 69-82, to 2.5 ppm, over the salinity range from 8 °/oo to 40 °/oo, and from 0 to 20 °C.
The effects of density extrema on buoyancy-induced flows in water are analyzed using a new density relation for pure and saline water. This new equation-of-state is accurate in the vicinity of maximum density for a wide range of temperature, salinity and pressure. Vertical boundary layer flows resulting from the simultaneous diffusion of momentum, thermal energy and salinity are considered. The simplicity of the temperature dependence of the density relation permits a buoyancy force formulation which dispenses with previously encountered restrictions, and results in a minimum number of additional new parameters. Conditions for similarity are determined considering all important physical effects and a new Grashof number arises which correctly reflects the vigor and direction of the flow near density extrema. Extensive calculations are presented for a vertical isothermal surface for a wide range of Prandtl number and pressure levels, for flows without salinity gradients. Heat transfer and convective inversion predictions are in good agreement with recent previous measurements for a melting vertical ice slab in pure water. The possibility of multiple extrema in combined diffusion flows was investigated.

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STATE UNIVERSITY OF NEW YORK AT STONY BROOK, Marine Sciences Research Center, Stony Brook, N. Y. 11794. F. G. Roberts, Associate Director.

106-09001-870-00

POLLUTION TRANSPORT MECHANISMS IN THE EAST RIVER, NEW YORK

(*b*) The Research Foundation of the State University of New York.
(*d*) Experimental and theoretical; applied research.
(*e*) Investigate the complex tidal, estuarine, and non-tidal transport mechanisms of the East River. These mechanisms are responsible for the transport of large quantities of sewage effluents, originating in the New York Harbor and the East River itself, into Long Island Sound. Although the tidal characteristics of the East River, as a hydraulic tidal strait, are relatively well-documented, the historical data on the non-tidal fluxes are extremely confused. A large collection of tidal, current, meteorological and sewage data is held by various governmental and city agencies. These data are being analyzed using established hydrodynamical methods to understand and quantify these various mechanisms. These results will enable more accurate estimates to be made of sewage effluent flux from the East River into Long Island Sound.
(*f*) Completed.
(*g*) About 400 MGD of sewage effluent is transported by the East River into western Long Island Sound. This represents ~ 32 percent directly into the entire Sound. This figure also represents ~ 70 percent of effluents released from the four sewage plants in the Upper East River. The remaining 30 percent is transported to New York Harbor.
(*h*) **The Hydrodynamic Characteristics of the East River Tidal Strait, New York,** M. J. Bowman, *Mèmoires Sociètè Royale des Sciences de Liege*, *Tome X*, pp. 165-174, 1976.

Tidal Locks Across the East River: An Engineering Solution to the Rehabilitation of Western Long Island Sound, *Estuarine Processes* **1**, pp. 28-44, 1976.
The Tides of the East River, New York, *J. Geophys. Res.* **81,** 9, pp. 1609-1616, 1976.
The Physical Oceanography and Water Quality of New York Harbor and Western Long Island Sound, *Tech. Rept. No. 23*, Marine Sciences Research Center, 1975.

106-10058-870-10

FIELD INVESTIGATION OF THE NATURE, DEGREE AND EXTENT OF TURBIDITY GENERATED BY OPEN-WATER PIPELINE DISPOSAL OPERATIONS

(*b*) Army Corps of Engineers.
(*c*) Dr. J. R. Schubel or H. H. Carter.
(*d*) Field investigation, applied research.
(*e*) Studies at five selected dredging sites for a quantitative investigation of turbidity generated by open-water pipeline disposal operations. The objective is to construct a simple mathematical model that can be used to predict the extent and character of turbid plumes without the need for extensive field studies.

106-10059-470-44

EFFECTS OF BATHYMETRIC CHANGES ASSOCIATED WITH SAND AND GRAVEL MINING ON CIRCULATION IN LOWER NEW YORK HARBOR

(*b*) Sea Grant.
(*c*) R. E. Wilson, Asst. Professor.
(*d*) Theoretical, applied research.
(*e*) Using a vertically integrated hydrodynamical-numerical model, determine changes in the tidal and residual circulation in the Lower Bay that would result from various sand and gravel mining strategies. Assess the environmental impact of the altered circulation patterns.

106-10060-220-36

SUSPENDED SEDIMENT DATA FROM THE CHESAPEAKE AND DELAWARE CANAL

(*b*) EPA.
(*c*) J. R. Schubel, Director.
(*d*) Theoretical, applied research.
(*e*) Reduction and interpretation of existing suspended sediment samples to determine the suspended sediment dispersal system of the Canal.

106-10061-100-54

THE PHYSICAL CHEMISTRY OF SILICIC ACID IN SEAWATER

(*b*) National Science Foundation.
(*c*) Dr. Iver W. Duedall.
(*d*) Theoretical and experimental, basic research.
(*e*) Determine experimentally the partial molar volume and partial molar compressibility of silicic acid in various ionic media at temperatures, pressures and concentrations encountered in the ocean environment.

NORTHERN MICHIGAN UNIVERSITY, School of Arts and Sciences, Department of Geography, Earth Science and Conservation, Marquette, Mich. 49855. Dr. John D. Hughes, Department Head.

107-06053-440-00

DRIFT BOTTLE STUDY OF THE SURFACE CURRENTS OF LAKE SUPERIOR

(*c*) Dr. John D. Hughes, Professor.
(*d*) Field investigation; basic research.
(*e*) To determine the surface current pattern of Lake Superior as it exists during each of the four seasons of the year.
(*f*) Suspended.
(*g*) 617 returns from 4845 drifters released (Dec. 1969). One preliminary qualitative paper published in Michigan Academician, Winter 1970.
(*h*) **Drift Bottle Study of the Surface Currents of Lake Superior,** *Michigan Academician* **III**, 4, Spring 1971. Reprints available from above address.

NORTHWESTERN UNIVERSITY, The Technological Institute, Evanston, Ill. 60201.

108-08888-340-52

MODELING OF CLADDING AND FUEL MOTION IN A LOSS-OF-FLOW SITUATION FOR GAS COOLED FAST REACTOR SAFETY ANALYSIS

(*b*) Nuclear Regulatory Commission.
(*c*) Professor D. T. Eggen, Dept. of Engineering Sciences/Applied Mathematics.
(*d*) Develop models for safety analysis of gas-cooled fast reactors; experimental and numerical.
(*e*) Program includes both experiments and the development of analytical computer models of cladding and fuel motion under GCFR loss-of-flow conditions. Three series of scoping experiments of increasing complexity will be performed on the motion, freeze-out, and coolant channel plugging of molten cladding. Computer models of these and related phenomenon are to be developed.
(*f*) Testing and modeling continues.
(*g*) Several experiments have been completed using Pb/Sn simulated and stainless steel cladding to study freezing in lower blanket. Analytical and numerical models have been correlated with the experiments. Melting experiments with loss of flow have been initiated using Pb/Bi alloy. The effects of gas flow and spacers are being studied and a numerical model of the melting and motion is under development.
(*h*) **Simulation of Cladding Melting and Resolidification in GCFR under LOF Using Pb/Sn Alloy,** N. Chu, T. J. Scale, D. T. Eggen, *Trans. Amer. Nucl. Soc.*, 1976.
Simulation of Transient Freezing of Cladding in GCFR Blanket Channels, N. Y. Chu, D. T. Eggen, E. Khan, *Proc. Natl. Mtg. Fast Reactor Safety and Related Physics, CONF 761001*, p. 1993, Oct. 5-8, 1976.
Behavior of Fission Gas in Oxide Fuels in a Transient Overpower, T. Wehner, D. T. Eggen, *Proc. 4th SMiRT Conf.*, San Francisco, Aug. 1977, to be published.
The Effects of Spacers on the Blockage of Coolant Channels in Clad Melting Accidents, D. T. Eggen, T. J. Scale, S. Hsieh, *Proc. 4th SMiRT Conf.*, San Francisco, Aug. 1977, to be published.

UNIVERSITY OF NOTRE DAME, Department of Aerospace and Mechanical Engineering, Notre Dame, Ind. 46556. Professor K. T. Yang, Department Chairman.

109-08891-020-54

TURBULENCE MEASUREMENTS AND MODELING

(*b*) National Science Foundation.
(*c*) Professor R. Betchov.
(*d*) Theoretical and experimental, basic research.
(*e*) The process of fluid deformation and vorticity concentration in turbulent flows is studied. It is found that the stretching of the vorticity is always associated with collision between advancing fluid masses. This produces thin regions, where most of the energy dissipation occurs. Numerical models for three-dimensional time dependent flows give results which confirm data from hot-wire studies, and provide insight on the rate of deformation tensor in turbulent flow.
(*f*) Completed.
(*h*) **Numerical Simulation of Isotropic Turbulence,** R. Betchov, *Physics of Fluids* **18,** p. 1230, 1975.

254-330 O - 78 - 8

Phase Relations in Isotropic Turbulence, C. Lorenzen, R. Betchov, *Physics of Fluids* **17**, p. 1503, 1975.
Non-Gaussian Events in Turbulent Flows, R. Betchov, *Physics of Fluids* **17**, p. 1509, 1975.

109-08896-630-50

INFLUENCE OF BLADE LOADING ON THE ACOUSTIC RESPONSE OF A CASCADE

(*b*) NASA, Lewis Research Center.
(*c*) Assoc. Professor H. Atassi.
(*d*) Theoretical, basic research.
(*e*) The unsteady lift forces acting upon cascade blades in a nonuniform flow are investigated. The study accounts for the effects of the different parameter of the cascade, namely, the aerodynamic load, angle of attack, camber and thickness of cascade blades, cascade solidity, stagger angle, and deviation angle. The results will be applied to calculating the dipole noise field as well as the quadruple originated noise. Optimization and sensitivity studies will equally be carried out so as to determine the optimal parameters of the cascade yielding minimum fluctuating lift for a given aerodynamic performance.
(*h*) **Influence of Loading on the Unsteady Aerodynamics of Turbomachine Blades,** H. Atassi, *Unsteady Flows in Jet Engines, Proc. Intl. Workshop*, United Aircraft Research Lab., pp. 449-464, 1974.
Influence of Loading on the Sound Field of Turbomachine Blades at Low and Moderate Mach Numbers, H. Atassi, *Transportation Noise, Proc. 3rd Interagency Symp. University Research*, Univ. of Utah, pp. 352-360, Nov. 1975.
Effect of Loading and Rotor Wake Characteristics on the Acoustic Response of Stator Blades, H. Atassi, *AIAA Paper 76-566*, 1976.
Unsteady Aerodynamic Forces Acting on Loaded Two-Dimensional Blades in Nonuniform Incompressible Flows, H. Atassi, *IUTAM Symp. Aeroelasticity in Turbomachines*, Paris, pp. 47-56, 1976.

109-08897-030-54

EFFECTS OF TURBULENCE AND SHEAR ON FLOW PAST BLUFF BODIES

(*b*) National Science Foundation.
(*c*) Professor A. A. Szewczyk.
(*d*) Experimental, basic research.
(*e*) Determine the effect of shear on the flow past finite bluff bodies. It is envisioned that the initial investigation will take place with a tailored linear velocity profile with low turbulence. In later studies the effect of turbulence superimposed on the shear flow will be studied past the same bluff bodies used in the initial experiments. The following sets of experiments will be carried out: 1) investigation of shear flow with low intensity turbulence, 2) investigation of a shear flow with medium intensity turbulence, and 3) investigation of a shear flow with high intensity turbulence.
(*h*) **Flow Characteristics of a Bluff Body in a Low Turbulence, Shear Flow,** A. A. Szewczyk, *Proc. 12th Biennial Fluid Dynamic Symp.*, Poland, 1975.

109-08901-870-70

PRESSURE DROP IN FABRIC FILTRATION

(*b*) Dustex, Division of American Precision Industries.
(*c*) Assoc. Professor T. Ariman.
(*d*) Theoretical and experimental, applied research.
(*e*) An analytical and experimental research program has been underway to develop a semi-empirical model for the determination of the pressure drop during the filtration process of dust laden gases. Particle size and size distribution, particle shape, gravity, dust cake thickness, gaseous properties, such as viscosity and density, filtering velocity, relative humidity, temperature, cleaning mechanism and fabric structure have been incorporated into the proposed pressure-drop model. An experimental program based on a bench scale filter system and a dust bag simulator has been underway for the correlation of the pressure drop formulation.
(*h*) **Electrostatic Filtration and the Apitron–Design and Field Performance,** D. J. Helfritch, T. Asiman, *Workshop on Novel Concepts, Methods, and Advanced Technology in Particulate-Gas Separation*, Univ. of Notre Dame, Apr. 1977.

109-08902-270-54

TRANSPORT PHENOMENA RELATED TO PROSTHETIC HEART VALVE THROMBUS FORMATION AND ERYTHROCYTE DAMAGE

(*b*) National Science Foundation.
(*c*) Professor T. J. Mueller and Assoc. Professor J. R. Lloyd.
(*d*) Experimental; applied and basic research.
(*e*) The transport phenomena in the vicinity of prosthetic heart valves are studied numerically and experimentally. Extensive data have been obtained with hot wire/film techniques which provide insight into the shear and normal stresses which the red blood cells experience as they flow through the valve. Shear stresses sufficient to damage erythrocytes have been found. Mass transfer rates have been measured around disc and ball valve prosthesis, and numerical prediction for low Reynolds number flows have been performed as a basis for comparison of the results.
(*h*) **In Vitro Measurements of Fluid Stresses in the Vicinity of a Disc-Type Prosthetic Heart Valve,** R. S. Figliola, T. J. Mueller, *Proc. 29th Ann. Conf. Engrg. in Medicine and Biology*, Boston, Nov. 1976.
Shear Induced Variations in Red Blood Cell Morphology, J. R. Lloyd, T. J. Mueller, P. C. Johnson, E. H. MacDonell, *ASME 1976 Advances in Bioengineering*, pp. 30-32, 1976.

109-08906-890-54

FIRE AND SMOKE SPREAD IN CORRIDORS

(*b*) National Bureau of Standards.
(*c*) Professors K. T. Yang, J. R. Lloyd, A. M. Kanury, S. T. McComas, V. W. Nee, A. A. Szewczyk.
(*d*) Theoretical and experimental, basic and applied research.
(*e*) This study is directed toward a better understanding of fire and smoke spread, and is to be accomplished through the development of numerical analytical models which can be used for predictive as well as guidance purposes. Radiation effects will be fully accounted for in these models. Data gathered at NBS and the University of Notre Dame will be used for an assessment of the validity of the analytical approach. The analysis will be applied to small-scale and full-scale fire spread problems such as the E-84 tunnel, model corridors, the full-scale corridor, to mention a few applications. With the availability of such an analysis, the relationship in terms of scaling between full-scale and small-scale tests can be examined. The analysis can be used for guidance on the usefulness of hazard tests as well as explaining the behavior of full-scale tests.
(*h*) **Numerical Modeling of Unsteady Buoyant Flows Generated by Fire in a Corridor,** A. C. Ku, M. L. Doria, J. R. Lloyd, *16th Intl. Symp. on Combustion*, Aug. 1976.

109-08907-140-54

HEAT TRANSFER IN NEAR SUPERCRITICAL TURBULENT FLOW IN PIPES

(*b*) National Science Foundation.
(*c*) Professor K. T. Yang.
(*d*) Theoretical, basic research.
(*e*) Develop a rational semi-empirical theory based on relevant physical mechanisms which are known to affect the heat transfer characteristics for turbulent pipe flow of near supercritical fluids. Anomalies relative to pipe size, pipe orientation, and level of heat flux with existing data are examined in detail.

109-08908-140-54

RADIATION INTERACTION IN CONVECTIVE HEAT TRANSFER

(*b*) National Science Foundation.
(*c*) Assoc. Professor J. R. Lloyd and Professor K. T. Yang.
(*d*) Theoretical and experimental, basic research.

(*e*) An analytical and experimental investigation of the interaction of thermal radiation with convection. The investigation will center on situations arising in combustion problems such as non-homogeneous gases and geometries that require finite-difference solutions. Although this proposal is centered on two specific problems, the basic knowledge gained from this research can be extended to other situations where the interaction of radiation with the other modes of heat transfer is important. The ability of being able to realistically predict the influence of radiation on heat transfer in furnaces, combustors, and unwanted fire spread as well as on pollutant formation, to cite a few examples, is extremely important.

(*h*) **Local Nonsimilarity Applied to Free Convection Boundary Layers with Radiation Interaction,** J. L. Novotny, J. R. Lloyd, J. D. Bankston, *AIAA Progress in Astronautics and Aeronautics* **39,** p. 309, 1975.

109-10118-030-26

HIGH ANGLE OF ATTACK SUPPORT INTERFERENCE

(*b*) Air Force Office of Scientific Research.
(*c*) Asst. Professor R. C. Nelson.
(*d*) Experimental, basic research.
(*e*) The influence of sting or strut support systems on the flow field around slender bodies of revolution at large angles of attack is studied experimentally. Data will include pressure distribution around the cylinder, pressure drag coefficient and wake characteristics over a Reynolds number of 10^4 to 3×10^5. These data will be useful for designing improved support systems which minimize model-support interference as well as providing a means of correcting existing high angle of attack aerodynamic measurements.

109-10119-630-50

CORRELATION OF SINGLE STAGE DATA TO OBTAIN IMPROVED MODELS FOR LOSS IN AXIAL COMPRESSORS

(*b*) NASA Lewis Research Center.
(*c*) Asst. Professor W. B. Roberts.
(*d*) Theoretical, basic research.
(*e*) The available single stage data generated by the NASA research effort over the past decade are analyzed. The data provide a detailed examination of the flow entering and leaving the blade rows in multiple radial and circumferential locations and can be used to study loss effects around part span dampers, end wall-effects on blading performance, and to develop improved stall criteria.

109-10120-540-50

STUDY OF BURNING OF LIQUID POOLS IN REDUCED GRAVITY

(*b*) NASA, Lewis Research Center.
(*c*) Assoc. Professor A. Murty Kanury.
(*d*) Theoretical, basic research.
(*e*) The merits and demerits of conducting pool-burning research in space are assessed on the basis of a critical examination of the existing theoretical and experimental work in the field.

109-10121-020-54

TURBULENCE MODELING

(*b*) National Science Foundation.
(*c*) Professor R. Betchov.
(*d*) Theoretical and experimental, basic research.
(*e*) Three-dimensional turbulent flows are studied by numerical methods. A code already developed and tested against experimental results is expanded so that it can handle flows limited by simple walls as well as flows around moving walls, with sharp edges. The method is intended for flows at high Reynolds numbers. Laboratory experiments are conducted to compare results with that of the numerical calculations.

UNIVERSITY OF NOTRE DAME, Department of Civil Engineering, Notre Dame, Ind. 46556. Dr. James I. Taylor, Department Chairman.

111-08909-870-36

INTERDISCIPLINARY EVALUATION OF EUTROPHIC LAKE RESTORATION

(*b*) Environmental Protection Agency.
(*c*) T. L. Theis, Q. Ross, and R. Greene.
(*d*) Theoretical, experimental and field investigation; M.S. and Ph.D. theses.
(*e*) Demonstrate on a full-scale basis, a lake reclamation method, using a fly ash and lime treatment. The initial phases of the project have been devoted to research and development of the treatment methodology. The present project is devoted to the actual application of fly ash and lime to the east side of Lake Charles East which is a 20 acre over nutrified lake in Steuben County, Indiana. The emphasis of this project is the monitoring of the results of the treatment of the 7.2 acres of the east portion of the lake as compared to the control (west) side of the lake. Differences in the physical, chemical and biological characteristics between the treated and control sides will be noted with particular interest in the success of the treatment in retarding algal blooms and their related problems will be evaluated. In addition, the potential detrimental effects of the treatment method on higher trophic levels will be monitored. Water quality will be monitored to determine the probability of trace metal release downstream from the treated portion of the lake.

A second aspect of this project is to study some of the various aspects of lake eutrophication which are directly or indirectly related to reclamation methods by physical and chemical manipulation. Continued laboratory algal assay studies will be performed to determine algal regrowth in treated water, and the effect of cations on phosphorus uptake. Study is currently underway to determine the rate and extent of nutrient regeneration from algal decomposition and the availability of these nutrients for further algal growth during a growing season. Continued evaluation of trace metal releases from fly ash treatment will be conducted both in the laboratory and on a field basis in Lake Charles East as well as the uptake of these metals in the biological community. Another study will analyze the effect of fly ash on the growth, regrowth, and distribution of macrophytes in the lake.

(*g*) Results thus far suggest that certain power plant fly ashes are effective in retarding the release of phosphorus from lake sediments. Full scale treatment plus nutrient diversion has brought about much lower phosphorus levels and a shift in algal successional patterns away from blue-green species.

(*h*) **The Role of Sediments in Hypereutrophic Lakes: Factors Effecting Phosphorus Exchange,** P. J. McCabe, *Ph.D. Thesis*, 1977.

Eutrophic Lake Restoration by Phosphorus Control, B. P. J. Higgins, *Ph.D. Thesis*, 1977.

Effects of Sodium and Potassium Ions on Transport of Phosphorus in Selanastrum Capricornutum and Microcystis Aeruginosa, S. C. Mohleji, *Ph.D. Thesis*, 1976.

111-09911-820-52

THE CONTAMINATION OF GROUNDWATER BY HEAVY METALS FROM THE LAND DISPOSAL OF FLY ASH

(*b*) U.S. Energy Research and Development Administration.
(*c*) T. L. Theis, Asst. Professor.
(*d*) Theoretical, experimental laboratory and field investigations; M.S. and Ph.D. theses.
(*e*) Characterize and monitor in the field trace metals associated with power plant fly ash and fly ash disposal operations with special reference to groundwater and soil contamination. Studies include laboratory analysis of several kinds of fly ash utilizing selective chemical extrac-

tants in order to define the available fraction of trace metals. Intensive field investigations of disposal sites are being performed. A model of metal distribution patterns will be made.

(*g*) Results thus far indicate that relatively conservative trace metals (such as nickel and zinc) migrate most readily in the disposal environment under study. Soil distribution of heavy metals is dependent largely on the site hydrologic characteristics.

(*h*) **Sorbtive Characteristics of Heavy Metals in Fly Ash-Soil Environments,** T. L. Theis, J. J. Marley, R. O. Richter, *Proc. 31st Purdue Industrial Waste Conf.*, Purdue Univ., 1976.

Field Investigations of Trace Metals in Groundwater from Fly Ash Disposal, T. L. Theis, J. D. Westrick, J. J. Marley, *Proc. 32nd Purdue Industrial Waste Conf.*, Purdue University, 1977.

OAK RIDGE NATIONAL LABORATORY, P.O. Box X, Oak Ridge, Tenn. 37830. Dr. Herman Postma, Director.

112-09266-870-36

FILTRATION WITH CROSS FLOW

(*b*) Environmental Protection Agency and ERDA.

(*c*) James S. Johnson, Jr.

(*d*) Experimental and field investigation; applied research.

(*e*) Laboratory and field investigations of treatment of industrial and municipal waste streams by filtration carried out with cakes (dynamic membranes) appropriate to desired separations, from dissolved materials to particulates, the unifying aspect being circulation of the solution being filtered past the filter to control polarization and reduce fouling. Field tests have used a mobile low-pressure crossflow filtration unit for evaluation of solids-liquid separations after addition of physical-chemical additives to primary sewage effluent; a mobile intermediate and high pressure unit for ultrafiltration and hyperfiltration tests with municipal sewage and with textile wastes; and ultrafiltration and hyperfiltration pilot units now operating in a kraft pulping installation.

(*f*) Sewage studies completed, reported in EPA reports ORD 17030EOH01/70 (hyperfiltration) and EPA-600/2-76-025 (cross flow filtration). Textile work continued at Clemson University. Pulp mill ongoing.

(*g*) Only preliminary from pilot plants at International Paper Co. installation in Moss Point, Miss. Ultrafiltration (dynamic hydrous Zr(IV)-Si(IV) oxide membrane) of bleach plant caustic extract was carried to over 12 percent solids, with excellent removal of color and organics, and flux about 65 gpd/ft^2 at high water recovery. Hyperfiltration (dynamic hydrous Zr(IV) oxide-polyacrylate membrane) of decker effluents gave good removals, but flux decline from fouling was severe. Breakage of supports, particularly with hyperfiltration, indicates need for further development of ceramic tubes or identification of alternatives.

112-10021-340-55

NOISE DIAGNOSTICS FOR SAFETY ASSESSMENT

(*b*) Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission.

(*c*) D. N. Fry, Instrumentation and Controls Division, Bldg. 3500, ORNL, P.O. Box X, Oak Ridge, Tenn. 37830.

(*d*) Experimental: measurement and diagnostics of the fluctuating component (noise) from neutron detectors in nuclear reactors.

(*e*) Provide specialized engineering services (analytical, experimental, and technical review) to NRC in the areas of reactor surveillance, diagnostics, and loose-parts monitoring, making available the broad interdisciplinary skills, extensive reactor instrumentation and measurement science development experience, and advance experimental and analytical capabilities of the Laboratory. These services will aid NRC in evaluating the performance of specific nuclear power plants now in operation and assessing the adequacy of existing noise monitoring and diagnostic techniques; and reviewing and upgrading surveillance instrumentation designs and diagnostic procedures currently in the planning stage. As deemed desirable by NRC, we will perform diagnostic measurements in operating nuclear power plants suspected of anomalous behavior and/or review measurement performed by others; and demonstrate analytical methods by which observable quantities may be related to unobservable physical properties of interest within the nuclear steam supply system.

(*g*) Neutron noise specialists Dwayne Fry and Bob Kryter and their groups, composed of Instrumentation and Controls Division staff and consultants and students from the University of Tennessee, provided measurement and consulting services to the Office of Nuclear Reactor Regulation which resulted in increased power production of BWR-4 reactors. When flow-induced, internal vibrations developed in eleven BWR-4 reactors, NRC requested that ORNL provide technical assistance in diagnosing the problem, determining its safety implications and determining a safe operational power level for each reactor. This generic problem involved excessive vibrations of the instrument tubes that run the length of the core. These tubes were impacting nearby channel boxes, sometimes hard enough and frequently enough to wear holes in the adjacent fuel channel boxes. Since the integrity of the channel boxes must be maintained because of LOCA safety restrictions, NRC had to decide whether to shut down the reactors completely or to allow their operation at reduced power levels. By measuring the frequency spectrum of the fluctuating component (noise) of the signals from neutron detectors already installed inside these detector tubes, we and our colleagues from industry and the affected utilities determined not only which instrument tubes were vibrating but also which ones were impacting the adjacent fuel channel boxes. With this information at hand, the decision could be made to allow continued operation of these eleven reactors at a power level just below the value where channel box impacting occurred until a more thorough corrective action (changing the coolant flow pattern in the core) could be engineered and accomplished. The full impact of our contribution is hard to estimate, but in one particular plant our measurements showed that the reactor could be safely operated at a power level 20 percent higher than the value initially fixed by NRC when the vibration problem was first discovered. This single instance could have more than paid for the cost of research and development associated with ORNL's participation in this problem.

Our involvement is not yet completed. We are now monitoring the performance of reactors that have been modified by the manufacturer and are helping NRC prepare surveillance procedures for instrument tube vibrations so that better historical data will be available if problems of this type reappear.

(*h*) **Summary of ORNL Investigation of In-Core Vibrations in BWR-4s,** D. N. Fry, R. C. Kryter, M. V. Mathis, J. E. Mott, J. C. Robinson, *ORNL/NUREG/TM-101* (1977).

Inference of Core Barrel Motion from Neutron Noise Spectral Density, J. C. Robinson, F. Shahrokhi, R. C. Kryter, *ORNL/NUREG/TM-100* (1977).

Determination of Void Fraction Profile in a BWR Channel Using Neutron Noise Analysis, M. A. Atta, D. N. Fry, J. E. Mott, submitted as Tech. Note to *Nucl. Sci. Eng.* (1977).

Bandwidth-Related Errors in the Inference of PWR Barrel Motion from Ex-Core Neutron Detector Signals, J. C. Robinson, R. C. Kryter, *Trans. Amer. Nucl. Soc.* **24,** 1, pp. 413-415, Nov. 1976.

U.S. Experience with In-Service Monitoring of Core Barrel Motion in PWRs Using Ex-Core Neutron Detectors, R. C. Kryter, J. C. Robinson, J. A. Thie, submitted for presentation *Intl. Conf. on Vibration in Nuclear Plant*, May 9-11, 1978, Keswick, England.

112-10022-340-55

PWR-BLOWDOWN HEAT TRANSFER SEPARATE EFFECTS PROGRAM

(*b*) Nuclear Regulatory Commission.
(*c*) D. G. Thomas.
(*d*) Experimental and analytical applied research.
(*e*) The ORNL Pressurized-Water Reactor Blowdown Heat Transfer (PWR-BDHT) Program is an experimental separate-effects study of the relations among the principal variables that can alter the rate of blowdown, the presence of flow reversal and rereversal, time delay to critical heat flux, the rate at which dryout progresses, and similar time-related functions that are important to LOCA analysis. Primary test results are obtained from the Thermal-Hydraulic Test Facility (THTF), a large nonnuclear pressurized-water loop that incoporates a 49-rod electrically heated bundle. Supporting experiments are carried out in several additional test loops–the Forced Convection Test Facility (FCTF), a small high-pressure facility in which single heater rods can be tested in annular geometry; an air-water loop which is used to evaluate two-phase flow-measuring instrumentation; a transient steam-water loop which is also used to evaluate two-phase flow-measuring instrumentation; and a low-temperature water mockup of the THTF heater rod bundle, containing a large number of pressure taps and conductivity probes to quantify THTF bundle hydraulics using COBRA.
(*g*) Supporting two-phase flow instrumentation studies have shown that accurate reduction of two-phase flow data requires drag disk calibration and use of a two-velocity model; that increased gamma densitometer stability can be achieved by replacing scintillation detectors with high-pressure ionization chambers; that the signal-to-noise ratio of drag disks is substantially increased by replacing the disk with a full flow screen; and that the effective THTF turbine meter time constant may be markedly reduced by replacing the variable reluctance pickoff probes with an eddy current pickoff probe. Evaluation of mixing coefficients, β, for air-water flow in the THTF water mockup indicates that at the lowest mass flow rates, values of β were up to 10 times greater than the single-phase value, with the maximum occurring at the transition from bubbly to slug flow. At the highest flow rates the value of the two-phase mixing coefficient was only slightly greater than the single-phase value in the limited range for which data were obtained.
Thirteen powered rod blowdowns have been conducted in the THTF through March 1977. The first of these tests were made with powers up to 122 kW/rod and outlet subcooling of 20 °F (11 °C) on all 49 rods. Subsequent tests have been made with inactive (zero-power) rods at different locations. Depressurization rates, and core inlet and outlet mass flow rates are similar to the values predicted for a cold leg offset guillotine break obtained from SAR's for different vendor PWR's, except that inlet flow remains negative for 2 to 3 sec longer than predicted. This is believed to be due to the location of the pressurizer in the THTF.
In general, RELAP predictions of the thermal-hydraulic behavior of the coolant during transients was quite good. RELAP predicted the appearance of pressurizer fluid at vertical outlet spool piece; made an excellent prediction of the depressurization curve; made a very good prediction of fluid density for the first 12 sec of the transient but missed later events because of limitations on handling energy fronts; and did a reasonably good job of predicting both volumetric and mass flows.
At a power of 122 kW/rod and an outlet subcooling of ~ 22 °F (~ 12 °C), mean time to critical heat flux (CHF) was ~ 0.7 sec with a range of 0.2 to 3.2 sec. Decreasing the rod power and increasing the outlet subcooling increased the time to CHF somewhat. Some preliminary calculations of the transient heat transfer coefficient have been completed. In one case, the steady-state value of the heat transfer coefficient, h, was ~ 44,000 Btu/hr ft^2 °F; shortly after the occurrence of the CHF the value of h decreased to ~ 400 Btu/hr ft^2 °F and remained there until ~ 2 sec into the transient. From 2 until 12 sec into the transient the value of h was near ~ 100 Btu/hr ft^2. For the remainder of the transient the value of h oscillated between 2 and 100 Btu/hr ft^2 °F.
(*h*) The following reports are available from NTIS, U.S. Dept. of Commerce, 5285 Port Royal Road, Springfield, Va. 22161.
Project Description, ORNL PWR Blowdown Heat Transfer Separate Effects Program–Thermal Hydraulic Test Facility (THTF), *ORNL/NUREG/TM-2*, Feb. 1976.
Quarterly Progress Reports on Blowdown Heat Transfer Separate Effects Program: *ORNL/NUREG/TM-14*–Jan.-Mar. 1976; *ORNL/NUREG/TM-46*–Apr.-June 1976; *ORNL/NUREG/TM-61*–July-Sept. 1976; *ORNL/NUREG/TM-92*–Oct.-Dec. 1976.

112-10048-870-55

ANALYSES OF TEMPERATURE DISTRIBUTIONS IN WATER BODIES RECEIVING POWER STATION COOLING WATER DISCHARGES

(*b*) Nuclear Regulatory Commission, Energy Research and Development Administration, U.S. Army Corps of Engineers.
(*c*) Howard A. McLain, Group Leader.
(*d*) Theoretical; applied.
(*e*) Predictions and correlations of temperature distributions in water bodies receiving power station cooling water discharges as part of the environmental assessment of these stations. Receiving water bodies include rivers, lakes, coastal areas and estuaries. Existing analytical models are used and often these models are modified to apply to new situations. New predictive models are being developed on a generic basis.
(*h*) **A Critical Evaluation of the Nonradiological Environmental Technical Specifications; Vol. 2: Surry Power Plants Units 1 and 2,** S. M. Adams, P. A. Cunningham, D. D. Gray, K. D. Kumar, *Oak Ridge Natl. Lab. Rept. ORNL/NUREG/TM-70*, Feb. 1977.
A Critical Evaluation of the Nonradiological Environmental Technical Specifications; Vol. 3: Peach Bottom Atomic Power Station Units 2 and 3, S. M. Adams, P. A. Cunningham, D. D. Gray, K. D. Kumar, A. J. Witten, *Oak Ridge Natl. Lab. Rept. ORNL/NUREG/TM-71*, Apr. 1977.
Topical reports of the modified and new predictive models will be issued as work on each model is completed.

112-10049-870-55

DEVELOPMENT OF A UNIFIED TRANSPORT APPROACH FOR THE ASSESSMENT OF POWER PLANT IMPACT

(*b*) U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research.
(*c*) Dr. M. R. Patterson, Oak Ridge National Laboratory; Prof. A. H. Eraslan, University of Tennessee, Knoxville.
(*d*) Theoretical (computer modeling); applied research; primarily non-thesis.
(*e*) Hydraulic transport models and their associated computer codes are being developed and verified for the movement of thermal energy, sediment, dissolved and adsorbed radionuclides, and chemical species, primarily in the far-field. A separate task is concerned with matching of near- and far-field flow regimes. A systematic methodology exploits the common features of convective transport and dispersion for fast-transient, tidal-driven rivers, lakes, estuaries, and costal regions in estimating the impact of power plant operations. One and two dimensional models are being developed for each type of transport such that all models for a given dimensionality share common data sets for the basic geometrical and meteorological parameters. Preprocessors and graphics modules have been written to aid in preparation and display of data and results.
(*f*) Funded through FY 1977.

(*g*) Applications of the models have been made for a number of sites and documentation is being prepared.
(*h*) **Development of a Unified Transport Approach for the Assessment of Power-Plant Impact,** A. H. Eraslan, et al., *Rept. ORNL/NUREG/TM-89*, 47 pages, Mar. 1977.
A Kinetic Model for Predicting the Composition of Chlorinated Water Discharged from Power Plant Cooling Systems, M. H. Lietzke, *Rept. ORNL/NUREG-13*, 45 pages, Apr. 1977.
LINSED: A One Dimensional Multi-Reach Sediment Transport Model, D. E. Fields, *Rept. ORNL/CSD-15*, 84 pages, Oct. 1976.
GRAFAR: A Computer Code for Graphic Display of Input Data to the FAR2D/FAROUT Code, B. Thomas, J. L. Bledsoe, J. T. Holdeman, *Rept. ORNL/CSD/TM-22*, May 1977.
PREPR2: A Program to Aid in the Preparation of Input Data for the FAROUT Two-Dimensional Discrete-Element Code, J. T. Holdeman, *Rept. ORNL/CSD/TM-19*, May 1977.

112-10439-390-55

SOLUTION-MINING OF URANIUM

(*b*) U.S. Nuclear Regulatory Commission and U.S. Energy, Research, and Development Administration.
(*c*) M. Reeves, Bldg. 4500N, Rm. A-212.
(*d*) Theoretical.
(*e*) Computer codes have been developed to solve the appropriate water- and mass-transport equations. The purpose of this work is to predict both environmental impact and production rates.
(*h*) Report in preparation.

OHIO STATE UNIVERSITY, Department of Agricultural Engineering, Columbus, Ohio 43210. Dr. G. O. Schwab.

113-0165W-890-00

STABILIZATION OF STEEP LAND SLOPES

(*e*) For summary, see Water Resources Research Catalog **9**, 8.0363.

113-0382W-840-00

DRAINAGE SYSTEM DESIGN FOR POLLUTION CONTROL AND CROP PRODUCTION

(*e*) For summaries, see Water Resources Research Catalog **9**, 2.0816 and 4.0163.

OHIO STATE UNIVERSITY, Department of Agronomy, Columbus, Ohio 43210. Professor George S. Taylor.

114-10609-820-54

SIMULATING HEAT AND WATER FLOW DURING SOIL FREEZING AND THAWING

(*b*) National Science Foundation.
(*d*) Simulation; applied research.
(*e*) A numerical analysis study of simultaneous heat and water flow during freeze-thaw in soil. Flow cases are analyzed for various heat and water fluxes at the ground surface and for different initial water contents and temperature distributions. The simulation yields water and ice contents, temperature and water table elevations at various times. Frost thawing is simulated by expanding the soil matrix for large ice contents. The entire operation is programmed on an electronic computer. Fulfillment of the project objectives will yield information on the physical process of freezing and thawing and improve predictions of frost thawing for different soils.
(*g*) Evaluations have been made of water redistribution in soils during freeze-thaw and of water table recession during freezing. The agreement between simulated and experimental data has been demonstrated.
(*h*) **Numeric Results of Coupled Heat-Mass Flow During Freezing and Thawing,** G. S. Taylor, J. N. Luthin, *Proc. 2nd Conf. Soil-Water Problems in Cold Regions*, Amer. Geophysical Union, pp. 155-172, 1976.

OHIO STATE UNIVERSITY, Department of Chemical Engineering, Columbus, Ohio 43210. E. R. Haering, Acting Chairman.

115-07551-010-54

A VISUAL INVESTIGATION OF THE LAMINAR-TURBULENT TRANSITION

(*c*) Robert S. Brodkey or Harry C. Hershey.
(*d*) Experimental; basic; Doctoral theses.
(*e*) An experimental study into the basic mechanism of the entire laminar turbulent transition for both boundary layer and pipe flow, to elucidate clearly the steps that occur in the transition from laminar to turbulent flow and to clarify which, if any, theories apply for the various steps known to exist.
(*f*) Suspended until student assigned to project.

115-07552-020-54

TURBULENT MOTION AND MIXING

(*c*) Robert S. Brodkey.
(*d*) Experimental and theoretical; basic; Doctoral thesis.
(*e*) An experimental and theoretical approach to the basic interactions of turbulence and the mixing of a scalar quantity such as mass. Mixing of heat or mass in a turbulent field can in principle be determined from a knowledge of the existing turbulence in the system and the molecular properties of the material being mixed. The object is to accomplish this prediction.
(*f*) Completed, publications being prepared.
(*g*) A number of papers have been published by the investigators of this work. We have been able to accomplish the prediction for pipe flow in a mixing tank, and for a reactor configuration. Furthermore, we have been successful in extending the analysis to the prediction of the effect on chemical kinetics.
(*h*) **Turbulence in Mixing Operations,** ed. R. S. Brodkey, *Academic Press, Inc.* (1975).
Mixing in Turbulent Fields, in *Turbulence in Mixing Operations*, ed. R. S. Brodkey, *Academic Press, Inc.* (1975).
Turbulent Mixing Studies in a Chemical Reactor, in *Turbulent Mixing in Nonreactive and Reactive Flows*, ed. S. N. B. Murthy, *Plenum Press* (1975).
Turbulent Motion Mixing and Kinetics in a Chemical Reactor Configuration, R. S. Brodkey, K. N. McKelvey, H.-C. Yieh, S. Zakanycz, *AIChE J.* **21**, p. 1165 (1975).

115-07553-250-54

A VISUAL INVESTIGATION OF DRAG REDUCTION AND DRAG REDUCTION IN NONAQUEOUS SOAP SOLUTIONS

(*b*) National Science Foundation.
(*c*) Harry C. Hershey.
(*d*) Experimental; basic; Doctoral theses.
(*e*) Experimental study into the basic mechanism of drag reduction in pipe flow using high molecular weight polymer or soap solutions and into the laminar and turbulent behavior of soap solutions. Flow in the wall region of a drag reducing fluid is being compared visually to the flow of a pure solvent. The technique involves high speed photography of colloidal-size particles. A parallel investigation is studying the laminar and turbulent behavior of various aluminum soaps in nonaqueous solvents.

115-08216-010-54

VISUAL INVESTIGATION OF THE TURBULENT BOUNDARY LAYER

(*c*) Robert S. Brodkey or Harry C. Hershey.
(*d*) Experimental; basic; Doctoral theses.
(*e*) An experimental study into the basic mechanism of boundary layer flow with emphasis on the interaction of the inner and outer regions. Stereoscopic viewing of the flow has been accomplished and currently simultaneous anemometry measurements by hot-film and laser methods are being investigated.
(*h*) **Reynolds Stress and Joint Probability Density Distribution in the U-V Plane of a Turbulent Channel Flow,** R. S. Brodkey, J. M. Wallace, *Phys. Fluids* **20**, p. 351, 1977.
Mass Transfer at the Wall as a Result of Coherent Structures in a Turbulently Flowing Fluid, K. N. McKelvey, H. C. Hershey, S. G. Nychas, *Intl. J. Heat and Mass Trans.* (to appear).
Pattern Recognized Structures in Bounded Turbulent Shear Flows, J. M. Wallace, H. Eckelmann, *J. Fluid Mech.* (to appear).
Vorticity and Turbulence Production in Pattern Recognized Turbulent Flow Structures, S. G. Nychas, J. M. Wallace, H. Eckelmann, *Phys. Fluids Sup.* (to appear).

115-09835-130-00

TURBULENT MOTION AND MIXING OF SOLIDS

(*c*) Robert S. Brodkey.
(*d*) Experimental and theoretical; basic; Doctoral thesis.
(*e*) A cross-correlation technique has been developed to measure the turbulent statistics of solid particle motions in a turbulent field. A mixing tank was used to develop the complex flow field. Stereoscopic visualizations were used to aid in establishing the nature of the flow field.
(*g*) The cross-correlation technique can be used to establish the distribution of velocity vectors of solid particle motions in a complex three-dimensional flow field. Stereoscopic flow visualization can aid in understanding the nature of the flow field.

OKLAHOMA STATE UNIVERSITY, School of Mechanical and Aerospace Engineering, Stillwater, Okla. 74074. Dr. K. N. Reid, Professor and Head.

116-08939-250-54

FLOW VISUALIZATION OF DRAG REDUCING CHANNEL FLOWS

(*b*) National Science Foundation.
(*c*) Dr. W. G. Tiederman.
(*d*) Experimental basic research for Ph.D. and M.S. theses.
(*e*) The flow processes in the near-wall region of a fully developed, turbulent, two-dimensional channel flow are being studied. The flow processes are marked by dye, photographed and then analyzed to determine how small concentrations of long-chain polymer molecules alter the flow structure and thereby lower the viscous friction.
(*g*) Generally the polymer additives suppress the momentum exchange between the near-wall region of the flow and the outer region. While none of the mixing processes are totally suppressed, some are altered. As the amount of drag reduction increases, the high-momentum eddies in the outer regions of the flow do not pentrate as close to the wall. The characteristics of the longitudinal eddy structure in the wall region also change. The average spanwise spacing of these eddies increases as drag reduction increases. Similarly, the spatially averaged bursting rate of these low-momentum streaks also decreases as drag reduction increases.
(*h*) **An Experimental Investigation of the Near-Wall Flow Structure During Drag Reduction,** D. K. Oldaker, *M.S. Thesis*, Oklahoma State Univ., Dec. 1974.
Structure of the Viscous Sublayer in Drag-Reducing Channel Flow, W. G. Tiederman, A. J. Smith, D. K. Oldaker, *Proc. 4th Biennial Symp. Turbulence in Liquids*, Univ. of Missouri-Rolla, Sept. 1975.
An Investigation of the Bursting Events in Drag Reducing Turbulent Channel Flows, A. J. Smith, *M.S. Thesis*, Oklahoma State Univ., Dec. 1975.
Spatial Structure of the Viscous Sublayer in Drag-Reducing Channel Flows, D. K. Oldaker, W. G. Tiederman. Presented *IUTAM Symp. Structure of Turbulence and Drag Reduction*, Washington, D.C., June 1976.
Calculation of Velocity Profiles in Drag-Reducing Flows, W. G. Tiederman, M. M. Reischman, *Trans. ASME J. of Fluids Engrg.* **98**, p. 563, Sept. 1976.

116-08940-700-00

LASER DOPPLER ANEMOMETRY FOR TURBULENT FLOWS

(*b*) Air Force Office of Scientific Research.
(*c*) Dr. W. G. Tiederman, and Dr. D. K. McLaughlin.
(*d*) Experimental and theoretical; basic research for Masters and Doctoral theses.
(*e*) Define the operational limits of individual realization laser Doppler anemometry for the measurement of highly turbulent fluid flows. Major emphasis is placed on data reduction algorithms which account for biased sampling in naturally seeded flows.
(*g*) The technique has been successfully used to measure the mean velocity and turbulence intensities in several flow situations including a jet in cross flow, fully developed turbulent channel flow of water, and drag reducing channel flows of polymer solutions. Corrections have been developed and verified experimentally to account for biased sampling when the flow is uniformly seeded with a narrow range of particle sizes.
(*h*) **Experimental Evaluation of Sampling Bias in Individual Realization Laser Anemometry,** M. S. Quigley, *M.S. Thesis*, Oklahoma State Univ., Dec. 1975.
Effect of Finite-Size Probe Volume upon Laser Doppler Anemometer Measurements, M. E. Karpuk, W. G. Tiederman, *AIAA J.* **14**, p. 1099, Aug. 1976.
Experimental Evaluation of Sampling Bias in Individual Realization Laser Anemometry, M. S. Quigley, W. G. Tiederman, *AIAA J.* **15**, p. 266, Feb. 1977.

116-08941-440-61

HYDRAULIC MODELING OF MIXING IN STRATIFIED LAKES

(*b*) Oklahoma Water Resources Research Institute.
(*c*) Dr. P. M. Moretti and Dr. D. K. McLaughlin.
(*d*) Experimental, applied research for several M.S. theses.
(*e*) Lake models with vertical distortion and saline stratification are used to develop methods of modeling the dispersion of inflows and the operation of mechanical destratification devices. Results are verified against data from the prototype lakes.
(*g*) Destratification processes can be modeled by maintaining prototype Richardson number, on a time scale derived from the ratio of total water volume to the volume flow rate. The lower Reynolds numbers in the model lead to somewhat more abruptly stepped density profiles.
(*h*) **Evaluation of Hydraulic Models of Stratified Lakes,** P. M. Moretti, D. K. McLaughlin, *AIChE Mtg.* (Microfiche), Atlantic City, N.J., Aug. 1976.
Hydraulic Modeling of Mixing in Stratified Lakes, P. M. Moretti, D. K. McLaughlin, *J. Hydraulic Div., ASCE* **103**, HY4, pp. 367-380, Apr. 1977.

116-10571-610-12

HYDRAULIC VORTEX RESISTORS

(*b*) U.S. Army Harry Diamond Laboratories.
(*c*) Dr. Karl N. Reid.
(*d*) Experimental and analytical, applied research for Doctoral thesis.

(*e*) This project involves the derivation and validation of analytical models for symmetric and nonsymmetric hydraulic vortex resistors. The vortex resistor exhibits a negative temperature sensitivity in certain ranges of geometrical design and operation; it can be used as a temperature compensating resistor in fluid control systems.
(*g*) One-dimensional and two-dimensional steady-state and dynamic models have been derived for symmetric and nonsymmetric vortex resistors. Experimental data tends to confirm the validity of the models in certain ranges of operation. The feasibility of designing temperature-insensitive and compensating vortex resistors in practical sizes has been established.
(*h*) **An Analytical and Experimental Study of Hydraulic Vortex Resistors,** K. N. Reid, S. Hamid, *Rept. No. HDL-CR-76-028-1*, to the U.S. Army Material Development and Readiness Command, Harry Diamond Lab., Adelphi, Md., June 1976.

116-10572-030-82

FLOW-INDUCED VIBRATIONS IN TUBE BUNDLES

(*b*) Tubular Exchanger Manufacturer's Association, Woverine Tube Div., U.O.P., and State of Oklahoma.
(*c*) Dr. P. M. Moretti and Dr. R. L. Lowery.
(*d*) Experimental studies related to flow-induced vibrations in shell-and-tube heat exchangers, for several Masters theses.
(*e*) Determination of natural frequencies of tube bundles in air and water; and investigation of flow-induced vibration mechanisms in a water tunnel.
(*f*) Suspended.
(*g*) The influence of hydrodynamic inertia coupling between tubes has been identified for some combined motions.
(*h*) **A Critical Review of the Literature and Research on Flow-Induced Vibrations in Heat Exchangers,** P. M. Moretti, *Heat Transfer-Research and Design, AIChE Symp.* **70,** 138, pp. 185-189, 1974.
Natural Frequencies and Damping of Tubes on Multiple Supports, R. L. Lowery, P. M. Moretti, *AIChE Paper No. 1, ASME/AIChE Natl. Heat Transfer Conf.*, San Francisco, Aug. 11, 1975.
Structural Characteristics of Helical-Corrugated Heat-Exchanger Tubes, P. M. Moretti, R. L. Lowery, T. A. Withers, *ASME Paper 75-WA/HT-14, ASME*, Houston, Tex., Dec. 1, 1975.
Hydrodynamic Inertia Coefficients for a Tube Surrounded by Rigid Tubes, P. M. Moretti, R. L. Lowery, *Trans. ASME, J. Press Vessel Tech.* **98J,** 3, pp. 190-193, Aug. 1976.

OLD DOMINION UNIVERSITY, Institute of Oceanography, Norfolk, Va. 23508. Dr. John C. Ludwick, Institute Director.

117-08914-450-44

HYDRAULIC SENSOR INSTRUMENTATION OF A SHORE FACE IN A TIDAL, NON-TIDAL CURRENT CONVERGENCE ZONE–CAPE HENRY, VIRGINIA

(*b*) National Oceanic and Atmospheric Administration–Environmental Research Laboratory.
(*d*) Field investigation; applied research.
(*e*) Tide, wave, and current sensors are mounted on a sea floor tripod and hard-wired to shore. The purpose is to learn how to separate wave surge from other current fields.
(*f*) Nearing completion.
(*g*) In 9-15 m of water offshore of Virginia Beach, Va., currents are competent to move bed sediment 15 percent of the time. Tidal currents acting alone are incompetent. Aperiodic wind-generated and slope-generated currents meet the current deficits for transportation.

117-10614-700-52

RADIOACTIVE SUSPENDED SEDIMENT TRANSMISOMETER

(*b*) ERDA (Oak Ridge National Laboratories)/NOAA (Miami).
(*d*) Experimental, with field work; basic, and instrument and equipment design, development, and operation.
(*e*) The attenuation of a beam of radioactive particles is recorded as a function of time at an underwater location 5 cm, 20 cm, and 40 cm above a sand bed during tidal current sediment transport conditions.
(*g*) Second stage instrument has been constructed and is undergoing field tests.

OREGON STATE UNIVERSITY, School of Engineering, Corvallis, Oreg. 97331. W. L. Schroeder, Asst. Dean, Research and Graduate Studies.

118-09766-430-44

APPLICATIONS OF NONLINEAR RANDOM SEA SIMULATIONS FOR DESIGN OF OFFSHORE STRUCTURES

(*b*) U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Sea Grant College Program.
(*c*) R. T. Hudspeth, Asst. Professor of Civil Engineering.
(*d*) Theoretical analyses using measured field data recorded during Hurricane Carla in the Gulf of Mexico, Masters thesis.
(*e*) Evaluate methods for the nondeterministic dynamic analyses of offshore structures using an actual offshore platform with both theoretical and measured wave spectra. Evaluate the effects on the response of an offshore platform to a stochastic wave field by equivalently linearizing hydrodynamic damping.
(*f*) Completed June 30, 1977.
(*g*) Results include the effects of spectral shape on the root-mean-square response of an actual structure and the influence of the Winkler soil model on the natural frequency of the structure.

118-09768-430-44

DESIGN CRITERIA FOR OCEAN AND NEARSHORE STRUCTURES–WAVE FORCES ON PIPELINES

(*b*) U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Sea Grant College Program.
(*c*) J. H. Nath, Professor of Mechanical Engineering, and T. Yamamoto, Asst. Professor, Civil Engineering.
(*d*) The nature of the project is to develop design criteria for difficult ocean engineering problems, i.e., to gain knowledge on the true forces which act perpendicular to and parallel to the nearby boundary represented by the ocean floor, on time-dependent forces from vortex shedding as influenced by the nearby boundary, on the flow regimes, accelerations and velocities around the cylinder which can create devastating scour under pipes, and on the influence on hydrodynamic forces from marine growths which accumulate on pipes and cause deviations from smooth pipe conditions.
(*e*) The OSU Wave Research Facility will be utilized together with a three-inch diameter model mounted with a force measuring section at mid-span which will utilize strain gauge force dynamometers. The distance between cylinder and boundary will be varied as well as wave length, height and water depth. A four-inch diameter cylinder will be used with strain force dynamometers in the test section at mid-span. The OSU Wind Tunnel will be used with wind velocities up to 45 feet per second. Both free stream conditions and submergence in a boundary layer will be investigated. Turbulence measurements will be made behind a smooth cylinder (and if time permits behind the sand-grained roughened cylinders). The turbulence spectra will be recorded in analog form, digitized at the OSU Wave Research Facility. If time permits, an application of the

circle theorem to a smooth cylinder near a plane boundary subjected to the velocity potential of a small amplitude wave will be attempted.

(*f*) Completed.

(*h*) **Forces From Fluid Flow Around Objects,** J. H. Nath, T. Yamamoto, *Proc. 14th Intl. Conf. Coastal Engrg.*, Copenhagen, June 1974.

Yet Another Report on **Cylinder Drag or Wave Forces on Horizontal Submerged Cylinders,** *Engrg. Exp. Sta. Bull. 47*, 139 pages, Oreg. State Univ., Corvallis, Oregon, 1973.

Wave Forces on Cylinders Near a Plane Boundary, T. Yamamoto, J. H. Nath, L. S. Slotta, *J. Waterways, Harbors and Coastal Engrg. Div., ASCE* **100,** pp. 345-359, Nov. 1974.

118-09986-420-54

HYDRODYNAMIC FORCES ON A CIRCULAR CYLINDER NEAR A PLANE BOUNDARY

(*b*) National Science Foundation, Engineering Division, Mechanics Section, Fluid Mechanics Program.

(*c*) J. H. Nath, Professor, Mechanical Engineering, and T. Yamamoto, Asst. Professor, Civil Engineering.

(*d*) To determine the hydrodynamic forces parallel and perpendicular to the nearby boundary for oscillatory flow wherein the water particle displacements are several times the cylinder diameter. The wake formation influence on the forces, as influenced by the nearby boundary, were determined for high Reynolds numbers.

(*e*) The work consisted of oscillating a 12-inch diameter cylinder, with an instrumented center section, through a maximum of 20 feet displacement for Reynolds numbers ranging from 5×10^5 to 2×10^6.

(*f*) Completed.

(*h*) **High Reynolds Number Oscillating Flow by Cylinders,** *15th Conf. Coastal Engrg.*, Honolulu, Hawaii, July 1976.

118-09987-420-54

NONLINEAR RANDOM SEA SIMULATIONS IN AN OCEAN OF FINITE DEPTH

(*b*) National Science Foundation, Research Initiation Grant.

(*c*) R. T. Hudspeth, Asst. Professor of Civil Engineering.

(*d*) Theoretical evaluation of nonlinear simulation of random sea in an ocean of finite depth.

(*e*) Results applied to Oregon State University Wave Research Facility by programming PDP-11 mini-computer to drive a wave board.

(*f*) Completed.

(*g*) Theoretical spectral shapes compared in simulating nonlinear random waves by χ^2 error with Gram-Charlier distribution using measured statistics from hurricane generated waves.

118-09988-450-44

LABORATORY TESTS OF DRIFTING BUOYS

(*b*) NOAA Data Buoy Office, National Space Technology Laboratories.

(*c*) John H. Nath, Director, Environmental Fluid Dynamics Laboratory.

(*d*) Conducted test programs which provided data for validating a numerical model of a drifting buoy and drogue system and supplementary data on hydrodynamic characteristics of the system elements.

(*e*) A buoy was constructed to about a scale ratio of 1:4 for the spar-type buoy utilized by NDBO. The model was connected to a windowshade drogue by a tether and the bottom of the drogue was attached to a towing device which in turn was attached to the towing carriage at the OSU Wave Research Facility. The system was towed slowly and subjected to waves of various frequencies and wave heights.

(*f*) Nearly-completed.

118-09989-430-87

DYNAMIC SOIL/WATER PRESSURES UNDER CAISSONS

(*b*) Delft Hydraulics Laboratory, The Netherlands.

(*c*) J. H. Nath, Director, Environmental Fluid Dynamics Laboratory.

(*d*) To experimentally determine the dynamic pressures in sand under caissons due to standing waves and caisson motion.

(*e*) A large test was built in the OSU Wave Research Facility wherein a test caisson was placed on a specific type of sand and the caisson was subjected to water waves. Dynamic pore water pressures were measured in the foundation under the caisson and the caisson movements were measured.

(*f*) Nearly completed.

(*g*) Excellent measurements were made.

(*h*) Report in progress.

118-09990-430-52

BIOLOGICAL AND HYDRODYNAMIC INFLUENCES ON THE SCREENS OF THE INTAKE SYSTEMS OF OTEC

(*b*) United States Energy Research and Development Administration.

(*c*) J. H. Nath, Professor, Mechanical Engineering, and C. B. Miller, Assoc. Professor, Oceanography.

(*d*) To develop first order design criteria for the screens of the intakes of an ocean thermal energy conversion power plant (OTEC).

(*e*) To evaluate the plant and animal forms that must be excluded from the heat exchanger by the screens; to determine the hydraulic energy losses associated with candidate designs for the screens that evolve from the study and the development of design criteria.

118-09991-430-54

DYNAMICS OF TAUT MOORINGS FOR FLOATING BREAKWATERS

(*b*) National Science Foundation, Water Resources, Urban and Environmental Engineering.

(*c*) T. Yamamoto, Asst. Professor, Civil Engineering, and J. H. Nath, Professor, Mechanical Engineering.

(*d*) To experimentally investigate the fundamental problems in response of elastically moored floating breakwater to random waves as well as regular periodic waves.

(*e*) The OSU Wave Research Facility will be utilized. The project will concentrate on rectangular floating breakwaters at this time. The theoretical fundamental principle will be experimentally verified for small amplitude waves and nonlinear waves at two scales including one nearly prototype scale.

PENNSYLVANIA STATE UNIVERSITY, College of Engineering, Department of Aerospace Engineering, University Park, Pa. 16802. Dr. Barnes W. McCormick, Department Head.

119-08221-010-00

INVESTIGATION OF THE VISCOUS SUBLAYER

(*c*) John L. Lumley.

(*d*) Experimental, basic research.

(*e*) Extension of the work of Bakewell to measurement of space-time correlations among all components in the viscous sublayer, and extraction of three-dimensional space-time eigenvalue from the correlation measurements.

119-10043-550-50

FLOW PHENOMENA IN AXIAL FLOW INDUCERS

(*b*) National Aeronautics and Space Administration.

(*c*) Dr. B. Lakshminarayana.

(*d*) Experimental and theoretical; basic and applied research.

(*e*) To gain sufficient knowledge and understanding of the flow in axial flow inducers to permit a systematic improvement in the flow, based on such knowledge and understanding. The flow measurements carried out so far include detailed hot-wire survey of the rotor passage resulting in quantitative knowledge of the three-dimensional mean velocity, as well as the turbulence flow field. In addition, solution of the flow field, based on viscous equations of motion in rotating coordinates, has been obtained.
(*g*) See Item (e).
(*h*) **Three Dimensional Flow Field in Rocket Pump Inducers: Part 2,** B. Lakshminarayana, C. A. Gorton, *J. Fluids Engrg.* **99,** Series I, 1, p. 176, Mar. 1977.

119-10044-630-22

THREE-DIMENSIONAL FLOW THROUGH PROPELLER PUMPS

(*b*) Naval Sea Systems Command.
(*c*) Dr. B. Lakshminarayana.
(*d*) Experimental and theoretical; basic and applied research.
(*e*) Develop a method of predicting the three-dimensional inviscid effects and to verify the theory by experimental measurements. An additional objective is to study the effect of blade dihedral on the pump performance.
(*f*) Completed.
(*g*) A three-dimensional lifting surface theory has been developed to predict the potential flow around blades, represented by vortices and sources, spanning an annulus. A rotor was designed, built and tested (with air as the test medium) for comparison with the theory. Static pressures on a rotating blade were measured, with and without dihedral. The deviation of the flow from commonly used two-dimensional methods was found to be substantial. The agreement between theory and experiment was found to be good for the radial bladed case.
(*h*) **Three-Dimensional Potential Flow and Effects of Blade Dihedral in Axial Flow Propeller Pumps,** R. Howells, B. Lakshminarayana, *J. Fluids Engrg.* **99,** Series I, 1, p. 167, Mar. 1977.

PENNSYLVANIA STATE UNIVERSITY, College of Engineering, Department of Civil Engineering, Hydraulics Laboratory, University Park, Pa. 16802. Dr. Joseph R. Reed, Associate Professor.

121-08222-870-00

MODEL STUDY OF STORM SEWER EXIT BELOW AN OVERFLOW NAPPE

(*b*) College of Engineering Central Research Fund.
(*c*) Dr. Gert Aron, Assoc. Professor.
(*d*) Applied research; experimental.
(*e*) A model of an ogee overflow structure has been built and installed in a laboratory flume. A modeled storm sewer outlet emerges under the nappe of the overfall, thus using the characteristically low pressure at this point to increase the hydraulic gradient available in the sewer for full flow storm water conveyance.
(*f*) Suspended.
(*g*) Data thus far indicates no persistence in negative pressure in the outlet. However, atmospheric pressure at the outlet was maintained for flow conditions which could be expected to cause severe storm sewer back-up.

121-08223-200-00

UNIFORM FLOW RESISTANCE IN OPEN CHANNELS

(*c*) Dr. J. R. Reed.
(*d*) Applied research; experimental; Master's thesis.
(*e*) The effect of shape on the Manning equation has been studied in a variably sloped plywood flume utilized in an earlier project. A transition did connect rectangular and trapezoidal sections of the flume and at any given time the two shapes had identical flows and slopes. Study is being continued where the entire flume is rectangular.
(*g*) The Manning n values are significantly different for the rectangular and trapezoidal sections under the same flow conditions. In addition, the n values varied with flow in the rectangular section, but remained relatively constant in the trapezoidal section. Initial results in the rectangular flume appear to show the n values dependent on slope.
(*h*) **Variability of Manning's Roughness Coefficient in a Smooth Regular Shaped Non-Prismatic Channel of Constant Bottom Slope,** D. F. Garvey, *M.S. Thesis*, Penn. State Univ., Aug. 1975.

121-08928-200-00

EVALUATION OF FRICTION SLOPE AVERAGING TECHNIQUES FOR VARIED CHANNEL FLOW

(*b*) U.S. Army graduate fellowship.
(*c*) Dr. J. R. Reed.
(*d*) Analytical; applied research; Master's thesis.
(*e*) This research evaluates seven different energy gradient averaging techniques which are now used in direct step solutions of gradually varied flow profiles. One of the techniques tested was that used in HEC-2. Computer results of step computations in prismatic channels are compared against mathematically accurate solutions using numerical quadrature for increasingly shorter steps in a given channel reach. Both M and S profiles are analyzed. Chow's integration and a suggested improvement of it are also tested. Further study is being conducted on the development of an even better friction slope model.
(*g*) All techniques showed a convergence to the true length as the number of steps increased from 1 to 50. However, each technique remained consistently separated from all the others in the quality of its estimate for a given profile throughout the range of steps. Each profile type studied had its own best friction slope model. Overall, two models fared well: one reported in a textbook by Vennard, and another used by the U.S.G.S.
(*h*) **An Evaluation of Energy Gradient Averaging Techniques Used in Computing Varied Flow Profiles,** A. J. Wolfkill, *M.S. Thesis*, Penn. State Univ., May 1975.
Evaluation of Friction Slope Models, J. R. Reed, A. J. Wolfkill, *Rivers '76, Proc. 3rd Ann. Symp. Waterways, Harbors and Coastal Engrg. Div., ASCE* **II**, pp. 1159-1178, Colorado State Univ., Aug. 1976.

121-08929-870-65

QUANTITATIVE AND QUALITATIVE IMPLICATIONS OF URBAN STORM RUNOFF ABATEMENT MEASURES

(*b*) The City of Philadelphia in cooperation with the Institute for Research on Land and Water Resources.
(*c*) Dr. Gert Aron, Dr. A. C. Miller, et al.
(*d*) Analytical field investigation; developmental; Master's thesis.
(*e*) Develop viable alternatives to the extremely expensive replacements and/or additions to storm sewer networks of insufficient capacity. Situations were studied where no suitable reservoir sites were available at acceptable costs.
(*f*) Completed.
(*g*) An urban storm runoff model was developed which fills the gap between long-hand runoff estimating and highly complex computer models.
(*h*) Reports are being finalized.

121-10084-220-60

SEDIMENT FLOW PREDICTION AT HIGHWAY CONSTRUCTION SITES

(*b*) Pennsylvania Department of Transportation with the Federal Highway Administration.
(*c*) Dr. Arthur C. Miller, Asst. Professor.
(*d*) Field investigation; developmental; Master's theses.
(*e*) Develop a method to predict sediment erosion from Pennsylvania highway construction sites which are instrumented by U.S.G.S.

121-10085-710-00

DETECTION OF SOIL MOISTURE LEVELS BY REMOTE SENSING

(*c*) Dr. David F. Kibler, Assoc. Professor, and Dr. Gert Aron.
(*d*) Experimental; applied research; Master's thesis.
(*e*) The feasibility of using multi-spectral scanner data to detect soil moisture changes on natural watersheds and spray irrigation plots is being studied.
(*g*) Preliminary results show more promise for irrigated plots than for natural watersheds.

121-10086-300-60

MODEL STUDY OF LOYALSOCK CREEK

(*b*) Pensylvania Department of Transportation.
(*c*) Drs. Arthur C. Miller and Ronald A. Chadderton, Asst. Professors.
(*d*) Experimental; design; Master's thesis.
(*e*) A model of a meander immediately upstream from a state highway is being constructed as an aid in the design of channel stabilization devices.

PENNSYLVANIA STATE UNIVERSITY, College of Engineering, Department of Mechanical Engineering, University Park, Pa. 16802. Dr. Donald R. Olson, Department Chairman.

122-08930-630-50

UNSTEADY BLADE PRESSURES

(*b*) NASA, Lewis Research Center, and Naval Sea Systems Command.
(*c*) Professor Robert E. Henderson.
(*d*) Experimental and theoretical; applied research, M.S. thesis.
(*e*) An instrumented blade is being developed to permit the measurement of unsteady pressure distribution on the rotor of an axial flow fan operated in a spatially varying inlet flow. A series of miniature pressure transducers are located along the blade chord to give the instantaneous pressure. The measurements will be compared with available unsteady cascade theories to demonstrate the effects of stagger angle, solidity and reduced frequency on the unsteady blade pressure distribution and lift.
(*h*) **Unsteady Pressure Distributions of Airfoils in a Cascade,** R. E. Henderson, E. P. Bruce, R. Specht, *Proc. Symp. Transportation Noise*, Nov. 1975.

122-08931-060-70

WALL PLUMES

(*b*) U.S. Department of Commerce, National Bureau of Standards, Center for Fire Research.
(*c*) Professor G. M. Faeth.
(*d*) Theoretical and experimental; M.S. and Ph.D. thesis research.
(*e*) The investigation considers the properties of laminar and turbulent thermal plumes along upright surfaces. Parameters of interest include mean velocity and temperature profiles, turbulence quantities, and heat transfer rates to the wall. Both combusting and noncombusting plumes are considered for two-dimensional flow conditions.
(*g*) Measurements have been completed for mean velocity and temperature profiles on vertical adiabatic and isothermal walls. Turbulence quantities and heat transfer rates have been measured for the isothermal wall. Correlations of mean quantities and heat transfer rates have been obtained through the assumption of local similarity in the plumes. Measurements in laminar combusting plumes have also been completed which agreed with predicted characteristics from numerical integration of the boundary layer equations.
(*h*) **Measurements In a Two-Dimensional Thermal Plume Along a Vertical Adiabatic Wall,** J. J. Grella, G. M. Faeth, *J. Fluid Mech.* **71,** pp. 701-710, Oct. 1975.
Theory of a Steady Laminar Thermal Plume Along a Vertical Adiabatic Wall, J. A. Liburdy, G. M. Faeth, *Letters in Heat and Mass Transfer* **2,** pp. 407-418, 1975.
An Experimental Investigation of a Turbulent Thermal Plume Along An Isothermal Wall, J. A. Liburdy, G. M. Faeth, *Symp. on Turbulent Shear Flows*, Penn. State Univ., University Park, Pa., Apr. 1977.
Investigations of Thermal Plumes Along Vertical Surfaces, J. A. Liburdy, *Ph.D. Thesis*, Penn. State Univ., University Park, Pa., Dec. 1976.

122-10020-290-50

SPRAY COMBUSTION

(*b*) National Aeronautics and Space Administration.
(*c*) Professor G. M. Faeth.
(*d*) Theoretical and experimental; M.S. and Ph.D. thesis research.
(*e*) The investigation considers the properties of liquid fuel combustion as a spray in a stagnant environment. Parameters of interest include profiles of mean quantities in both combusting and noncombusting sprays with axial symmetry.
(*g*) Measurements of spray boundaries have been completed for combusting sprays at pressures from 1-90 bar. A locally homogeneous integral model of the two phase process, which was developed for gas-gas and gas-liquid flows, was found to underpredict the spray boundaries, suggesting important slip effects for liquid-gas systems.
(*h*) **High Pressure Spray Combustion,** A. J. Shearer, *M.S. Thesis*, Penn. State Univ., University Park, Pa., June 1977.

PENNSYLVANIA STATE UNIVERSITY, Institute for Research on Land and Water Resources, University Park, Pa. 16802. Dr. John C. Frey, Director.

123-09836-860-33

PREDICTION OF WATER TEMPERATURE FOR THERMALLY-LOADED STREAMS

(*b*) USDI, Office of Water Research and Technology and Agricultural Experiment Station, Penn State University.
(*c*) David R. DeWalle, Assoc. Professor of Forest Hydrology.
(*d*) Field and theoretical investigation, both applied and basic research, non-thesis.
(*e*) Determine effects of atmospheric stability, wind direction, and vegetative shade removal on heat exchange of streams with applications to thermal-loading problems.
(*g*) A modified form of Shulyakovskiiy's evaporation equation can adequately account for unstable atmospheric effects over thermally-loaded streams. Wind direction and velocity must be used for streams to compute relative velocity of air with respect to water. Shade removal on small streams causes natural thermal pollution great enough to cause a fourfold increase in the diurnal range of water temperature at a given stream depth. Forest streams flowing into unshaded reaches will heat in a nearby linear fashion with downstream distance until water temperature increases sufficiently to permit temperature-dependent heat loss to compensate for solar radiation gains. Channel bottom conduction may be a major energy exchange mechanism for streams flowing through unshaded reaches.
(*h*) **Effect of Atmospheric Stability on Water Temperature Predictions for a Thermally Loaded Stream,** D. R. DeWalle, *Water Resources Res.* **12,** 2, 1976.
Estimating Effects of Summer Water Temperatures of Small Streams, D. R. DeWalle, W. M. Kappel, *Proc. Soc. Amer. Foresters*, 1974.
Predicting the Effect of Shade Removal on Maximum Stream Temperatures, D. R. DeWalle, S. L. Taylor, J. A. Lynch, *3rd Intl. Hydrol. Symp., IAHS*, 1977.

PENNSYLVANIA STATE UNIVERSITY, Institute for Science and Engineering, Applied Research Laboratory, P.O. Box 30, State College, Pa. 16801. J. C. Johnson, Laboratory Director.

124-03807-230-50

THERMODYNAMIC EFFECTS ON CAVITATION

(*b*) National Aeronautics and Space Administration.
(*c*) Dr. J. William Holl.
(*d*) Experimental and theoretical.
(*e*) Investigations are carried out in the high speed cavitation tunnel employing various working fluids. At the present time, the primary fluid is Freon 113. Thermodynamic effects are investigated for both developed and limited cavitation over a range of temperatures and velocities. Analytical investigations are also being conducted.
(*f*) Completed.
(*g*) The experimental data for developed cavitation obtained in this investigation and by other investigations was correlated in terms of an entrainment theory.
(*h*) **Thermodynamic Effects on Limited Cavitation,** J. W. Holl, M. L. Billet, D. S. Weir, *IAHR Symp.*, Grenoble, France, Mar. 1976.

124-08235-230-21

VORTEX CAVITATION

(*b*) David W. Taylor Naval Ship Research and Development Center, Naval Sea Systems Command.
(*c*) Dr. J. William Holl and Mr. M. L. Billet.
(*d*) Experimental and theoretical; basic research; Ph.D. thesis research.
(*e*) Study various forms of limited cavitation in vortex flows, i.e., vaporous and non-vaporous cavitation; determine the factors which control the $C_{P_{min}}$ of the vortex; noise characteristics.
(*h*) **Cavitation Research at the Garfield Thomas Water Tunnel,** J. W. Holl, R. E. A. Arndt, M. L. Billet, C. B. Baker, *Proc. Conf. on Cavitation*, Inst. Mech. Engr., Sept. 1974.

124-08236-230-22

THE EFFECT OF POLYMER ADDITIVES ON CAVITATION

(*b*) Naval Sea Systems Command.
(*c*) Dr. Roger E. A. Arndt; Dr. J. William Holl.
(*d*) Experimental and theoretical.
(*e*) Determine the effect of polymer additives on cavitation in a shear flow and on streamlined bodies.
(*f*) Completed.
(*h*) **Influence of Gas Content and Polyethylene Oxide Additive Upon Confined Jet Cavitation in Water,** C. B. Baker, J. W. Holl, R. E. A. Arndt, *Proc. ASME Cavitation and Polyphase Flow Forum*, 1976.
A Note of the Inhibition of Cavitation in Dilute Polymer Solution, R. E. A. Arndt, M. L. Billet, J. W. Holl, C. B. Baker, *Proc. ASME Cavitation and Polyphase Flow Forum*, 1976.

124-08916-230-22

SCALING LAWS FOR CAVITATION DAMAGE

(*b*) Applied Research Laboratory E&F Program, Naval Sea Systems Command.
(*c*) Dr. J. William Holl.
(*d*) Experimental and theoretical.
(*e*) Problem concerns the determination of scaling laws for cavitation damage in a flow system. Initial tests are concerned with effect of velocity on cavitation damage on ogive nosed bodies.
(*h*) **Scaling of Cavitation Damage,** D. R. Stinebring, *M.S. thesis*, Penn State University, 160 pages, Aug. 1976.
Scaling of Cavitation Damage, D. R. Stinebring, *AIAA 13th Ann. Mtg.*, Washington, D.C., Jan. 10-13, 1977.

124-08917-630-20

INVESTIGATION OF UNSTEADY FORCES AND MOMENTS ON AN AXIAL FLOW FAN ROTOR BLADE

(*b*) Office of Naval Research (Project SQUID), Naval Sea Systems Command.
(*c*) Mr. Edgar P. Bruce.
(*d*) Experimental and theoretical; basic research; Ph.D. thesis.
(*e*) Measure and analyze the unsteady normal force and pitching moment on the mid-span segment of a blade of an axial flow fan rotor operating in a flow whose axial velocity component varies sinusoidally in the circumferential direction. The program variables are blade camber, reduced frequency, blade space-to-chord ratio, blade stagger angle, and blade mean angle of attack. The experimental results will be used to provide design information and to assess the validity of available theoretical models.
(*g*) Test results are being reduced and analyzed at reduced frequencies from 0.2 to 5.0.
(*h*) **Design and Evaluation of Screens to Produce Multi-Cycle Sinusoidal Velocity Profile,** E. P. Bruce, *AIAA Paper 74-623*, July 1974.
The ARL Axial Flow Research Fan, E. P. Bruce, *ASME Paper 74-FE-27*, May 1974.
Axial Flow Rotor Unsteady Response to Circumferential Inflow Distortions, E. P. Bruce, R. E. Henderson, *Project SQUID Tech. Rept. PSU-13-P*, Sept. 1975.

124-08919-550-22

PROPELLER TIME-DEPENDENT THRUST DUE TO TURBULENT INFLOW

(*b*) Naval Sea Systems Command.
(*c*) Dr. Donald E. Thompson.
(*d*) Experimental and theoretical; basic research; Ph.D. thesis.
(*e*) Measurements of the time-dependent thrust generated by each of a series of propellers due to operation in various turbulent inflows have been made. The power spectra of the time-dependent thrust over a frequency range including blade passing frequency were made. Comparisons of the measured power spectra with those predicted by each of several analytical methods were made. It was shown that the broadband hump, centered at blade passing frequency, can be predicted and can be significant.
(*h*) **Propeller Time-Dependent Forces Due to Nonuniform Inflow,** D. E. Thompson, *Ph.D. Thesis*, Penn State University, Mar. 1976.

124-08920-160-21

RADIATED SOUND DUE TO ROTOR OPERATING IN A TURBULENT INFLOW

(*b*) David W. Taylor Naval Ship Research and Development Center.
(*c*) Dr. B. Lakshminarayana and Dr. Donald E. Thompson.
(*d*) Experimental and theoretical; applied research; M.S. thesis.
(*e*) Measurements were made of the radiated sound due to a ducted rotor operating in turbulent inflows with various length scales and intensities. Radiated sound spectra and directivity patterns were measured. Comparisons with predictions made with two different analytical methods were made. The parameters investigated include blade speed and flow coefficient. The current investigation centers on nonhomogeneous, nonisotropic turbulent inflows as produced by boundary layers, strut wakes, and secondary flows.
(*h*) **Noise Due to Interaction of Boundary Layer Turbulence with a Compressor or a Propulsor Rotor,** N. Moiseev, B. Lakshminarayana, D. E. Thompson, *3rd AIAA Aero-Acoustics Conf., Paper No. 76-568*, Palo Alto, Calif., July 20-23, 1976.
Noise Due to the Interaction of Boundary Layer Turbulence with a Marine Propulsor or an Aircraft Compressor, N. A. Moiseev, *M.S. Thesis*, Penn. State Univ., Mar. 1977.

124-08922-630-22

WOBBLE PLATE PUMP INVESTIGATION

(*b*) Naval Sea Systems Command.
(*c*) Walter S. Gearhart.
(*d*) Experimental and theoretical; applied research; M.S. thesis.
(*e*) The development and experimental evaluation of a pump configuration capable of pumping fluids with a high amount of suspended materials has been completed. The pump utilized a wobble plate impeller and a series of wobble plate geometries were evaluated to determine their head and capacity characteristics. A preliminary investigation of a configuration design to grind suspended solids as they passed through the pump was also completed.
(*f*) Completed.
(*h*) **Development of a Wobble Plate Slurry Pump,** G. Smith, W. S. Gearhart, H. D. Bartlett, presented *1976 North Atlantic Region Mtg.*, Rutgers Univ., Aug. 15-18, 1976.
Development of a Wobble Plate Slurry Pump, G. L. Smith, *M.S. Thesis in Agricultural Engrg.*, Penn. State Univ., 1975.

124-08923-550-22

RESEARCH AND DEVELOPMENT OF PROPULSORS FOR SUBMERGED VEHICLES AND HIGH SPEED SURFACE SHIPS

(*b*) Naval Sea Systems Command.
(*c*) Dr. R. E. Henderson and Mr. W. S. Gearhart.
(*d*) Experimental and theoretical; basic and applied research.
(*e*) A continuing program is being conducted to develop propulsors having specific performance goals with respect to noise, cavitation, weight and efficiency. Single and counterrotating propellers, ducted propellers, pumpjets, and waterjet propulsion devices are considered. Propulsor design, fabrication and experimental evaluations are conducted to determine the steady state propulsive and cavitation performance. Theoretical studies included propulsor trade-off evaluations, blade design and axisymmetric flow field predictions.
(*h*) **Refinement of the Mean-Streamline Method of Blade Section Design,** M. W. McBride, *ASME Paper 76-WA/FE-11*, Dec. 1976.
Cavitation Breakdown of a Pump Operating in Water Having a Dilute Polymer Concentration, M. L. Billet, W. S. Gearhart, *ARL TM 75-66*, Mar. 1975.

124-08924-550-22

ROTOR RESPONSE TO INLET DISTORTIONS

(*b*) NASA, Lewis Research Center; Naval Sea Systems Command.
(*c*) Dr. R. E. Henderson.
(*d*) Experimental and theoretical; basic research; M.S. thesis.
(*e*) The unsteady response of an axial-flow rotor to various inlet velocity distortions is studied by the investigation of the flow at the inlet and exit of the blades. The influences of rotor geometry–solidity, stagger angle, camber–are investigated. Detailed surveys of the flow field are conducted and the results compared with theoretical predictions.
(*h*) **The Response of Turbomachine Blades to Low Frequency Inlet Distortions,** J. H. Horlock, E. M. Greitzer, R. E. Henderson, *ASME Paper 76-GT-19*, 1976.

124-08926-030-22

MEASUREMENT OF FORCES ON MODELS IN A WATER TUNNEL

(*b*) Naval Sea Systems Command and Sandia Laboratories.
(*c*) Mr. George Gurney, Mr. W. R. Hall, and Mr. Fred E. Smith.
(*d*) Experimental; some basic and applied aspects.
(*e*) The program involves the measurement of body forces on various hydrodynamic configurations. Measurements were made over a range of velocities up to 73 ft/sec in non-cavitating flow. The drag changes due to the addition of appendages have been investigated. Forces on right circular cylinders of various end geometries and L/D ratios were obtained.
(*h*) **Experimental Determination of the Hydrodynamic Coefficients of Finite Circular Cylinders as a Function of Angle-of-Attack and Slenderness Ratio,** G. L. Sanders, W. R. Hall, G. B. Gurney, *ARL Report 75-05*, 8 Jan. 1975.

124-08927-030-22

TUNNEL WALL INTERFERENCE FOR BODIES OF REVOLUTION

(*b*) Naval Sea Systems Command.
(*c*) Mr. William R. Hall and Mr. Fred E. Smith.
(*d*) Experimental and theoretical.
(*e*) Body forces measured with large model-to-tunnel diameter ratio bodies require substantial corrections to predict vehicle performance under free-field condition. This investigation is intended to develop better corrections for various model configurations.
(*g*) New test programs using various body shapes have been developed. Hardware design in progress.

124-10045-630-31

RESEARCH INTO PREVENTION OF DRAFT-TUBE SURGING IN HYDRAULIC TURBINES AND PUMP-TURBINES

(*b*) Bureau of Reclamation, Denver, Colo.
(*c*) Walter S. Gearhart.
(*d*) Experimental and applied research.
(*e*) Evaluate a technique intended to prevent the occurrence of draft tube swirl in hydroelastic turbines and pump-turbines. The results of this program will be used to determine the feasibility of applying this method in preventing draft tube surging and to what range and type of turbomachine it is most applicable.

124-10046-630-21

THE EFFECT OF POLYMER ADDITIVES ON PUMP CAVITATION

(*b*) David W. Taylor Naval Ship R&D Center.
(*c*) Professor Walter S. Gearhart and Mr. M. L. Billet.
(*d*) Experimental and theoretical.
(*e*) Determine the effect of polymer additives on the pump performance near cavitation breakdown.
(*f*) Completed.
(*h*) **Cavitation Breakdown of an Axial Flow Pump Operating in Water Having a Dilute Polymer Concentration,** *Proc. Conf. Scaling for Performance Prediction in Rotordynamic Machines*, Univ. of Stirling, England, 6-8 Sept. 1977.

124-10047-230-22

APPLICATION OF LDA SYSTEM TO MEASURE CAVITATION NUCLEI

(*b*) Naval Sea Systems Command.
(*c*) Mr. M. L. Billet.
(*d*) Experimental.
(*e*) A method is being developed to measure the size and distribution of cavitation nuclei in a high-speed water tunnel.

UNIVERSITY OF PENNSYLVANIA, Department of Chemical and Biochemical Engineering, Philadelphia, Pa. 19174. E. B. Dussan V, Asst. Professor.

125-09951-100-54

MUTUAL DISPLACEMENT OF IMMISCIBLE VISCOUS FLUIDS

(*b*) National Science Foundation.
(*d*) Theoretical and experimental, basic research, for Ph.D. thesis.
(*e*) The mutual displacement of immiscible viscous fluids: The aim is to perform a detailed fluid mechanical analysis of

the flow near the moving contact line, and to deduce the appropriate boundary conditions needed to analyze the wetting and spreading of fluids on a solid surface; the aim is also to be able to predict dynamic contact angles.

(*h*) **Immiscible Liquid Displacement In A Capillary Tube: The Moving Contact Line,** *AIChE J.* **23,** pp. 131-133, 1977.
The Moving Contact Line: The Slip Boundary Condition, *J. Fluid Mech.* **77,** pp. 665-681, 1976.
On the Difference Between a Material Surface and a Boundary Surface, *J. Fluid Mech.* **75,** pp. 609-623, 1976.
Hydrodynamic Stability and Instability of Fluid Systems with Interfaces, *Archive for Rational Mechanics and Analysis* **57,** 4, pp. 363-379, 1975.
On the Motion of a Fluid-Fluid Interface Along a Solid Surface, (with S. H. Davis), *J. Fluid Mech.* **65,** pp. 71-95, 1974.

UNIVERSITY OF PITTSBURGH, School of Engineering, Department of Chemical and Petroleum Engineering, Pittsburgh, Pa. 15261. Dr. George E. Klinzing, Associate Professor and Graduate Coordinator.

126-08934-290-00

EXPERIMENTALLY DETERMINED EFFECT OF ARTIFICIALLY ROUGHENED SURFACES ON HYDRAULIC LOSS COEFFICIENTS

(*d*) Experimental, applied.
(*e*) Experimental data obtained for flow of water between "smooth" and an artificially roughened plate for the purpose of determining the effect of artificially roughened surfaces of moderate to large relative roughness. Reduced data indicates significant increase in the hydraulic loss coefficient which results in decreased flow rates between two parallel plates.
(*f*) Suspended.
(*h*) **Experimentally Determined Effect of Artificially Roughened Surfaces of Hydraulic Loss Coefficients,** *IEC Process Design & Development,* Apr. 1977.

126-09837-000-00

LAMINAR FLOW INSTABILITY

(*d*) Theoretical; applied.
(*e*) The stability of flow in single channels has been shown by analytical methods. Multiple channels present considerable difficulty in analysis and numerical techniques are employed with overall correlation of the stability criteria with the parameters of the system.
(*h*) **Temperature-Viscosity Induced Laminar Instabilities in a Gaseous Heated Channel,** *Nuclear Engrg. & Design* **40,** p. 225, 1977.

126-09838-130-00

PULSED FLUIDIZATION OF POWDERS

(*d*) Experimental; applied.
(*e*) The fluidization of powders of particles sizes 1-10 μm is only possible by use of pulsed flow. This pulsed technique is proposed as a method for characterizing powder properties in flow situations.

UNIVERSITY OF PITTSBURGH, Department of Civil Engineering, Water and Environmental Engineering Program, Pittsburgh, Pa. 15261. Professor Chao-Lin Chiu, Program Chairman.

127-08240-810-54

STOCHASTIC HYDROLOGIC SYSTEMS

(*b*) National Science Foundation.
(*c*) Dr. Rafael G. Quimpo.
(*d*) Theoretical with field investigation and data analysis.
(*e*) Stochastic models of hydrologic systems are investigated with a view of unifying their formulation under a common framework with models of parametric hydrology.
(*f*) Completed.
(*g*) A second order model for a hydrologic system was developed. The second order kernel was expressed in terms of two parameters. A parameter estimation technique from input-output data was developed.
(*h*) **Parameter Estimation in a Second Order Runoff Model,** R. G. Quimpo, Sun-Quan Yuan, presented *3rd Intl. Hydrology Symp.*, Fort Collins, Colorado, June 1977.

127-08935-300-54

SECONDARY CURRENTS IN NATURAL STREAMS AND RIVERS

(*b*) National Science Foundation.
(*d*) Analytical, with field data.
(*e*) Develop a technique and procedure for computing secondary currents in natural streams and rivers, and use the technique to study the characteristics, development, and sensitivity of secondary currents to various factors affecting them.
(*g*) A technique for computing secondary currents has been developed with which the three-dimensional structure of flow in streams and rivers can be computed, simulated, and analyzed. Such a result enables investigating many other transport processes in streams and rivers which are inherently three-dimensional.
(*h*) **Simulation of Hydraulic Processes in Open Channels,** Chao-Lin Chiu, H. C. Lin, K. Mizumura, *J. Hydraulics Div., ASCE* **102,** HY2, Feb. 1976.

127-09845-200-00

APPLICATIONS OF KALMAN FILTERING THEORY IN ESTIMATION OF HYDRAULIC PROCESSES

(*d*) Analytical, experimental.
(*e*) Modern estimation theory using Kalman filters is being tested for its effectiveness in estimation of parameters and variables of hydraulic systems, such as the open channel flow, stream temperature fluctuation, and sediment transport, etc.
(*g*) Early results indicate that the use of Kalman filtering can reduce the estimate-error variance and, hence, increase the accuracy of estimation.
(*h*) **Applications of Estimation Theory to Hydraulic Problems,** Chao-Lin Chiu, N. C. Matalas, D. R. Dawdy, K. Mizumura, *Proc. 2nd Intl. Symp. Stochastic Hydraulics,* Lund, Sweden, Aug. 2-4, 1976.
Application of Kalman Filter in Modeling Daily Stream Temperature, Chao-Lin Chiu, E. Isu, *Proc. XVII Cong. Intl. Assoc. Hydraulic Research,* Baden Baden, Germany, Aug. 15-19, 1977.

PRINCETON UNIVERSITY, Department of Aerospace and Mechanical Sciences, Moody Hydrodynamics Laboratory, Princeton, N.J. 08540. Professor Seymour M. Bogdonoff, Department Chairman.

128-10414-050-54

INCOMPRESSIBLE AXISYMMETRIC WAKES

(*b*) National Science Foundation.
(*c*) Dr. Francis R. Hama.
(*d*) Primarily experimental basic research.
(*e*) Characterization of unstable waves and clarification of turbulent breakdown mechanism in basically axisymmetric wakes behind various increasingly blunt bodies of revolution.
(*h*) **An Experimental Study of Instability and Transition in an Axisymmetric Wake,** L. F. Peterson, *Ph.D. Thesis,* 1975.
Axisymmetric Laminar Wake Behind a Slender Body of Revolution, F. R. Hama, L. F. Peterson, *J. Fluid Mech.* **76,** pp. 1-15, 1976.

Instability and Transition in Axisymmetric Wakes, F. R. Hama, L. F. Peterson, S. C. de la Veaux, D. R. Williams, *AGARD Laminar-Turbulent Transition Symp. Proc.*, 1977.

128-10415-010-20

BOUNDARY LAYER TRANSITION

(*b*) Office of Naval Research.
(*c*) Dr. Francis R. Hama.
(*d*) Experimental basic research in a newly constructed boundary layer channel.
(*e*) Detailed mapping of instantaneous, three-dimensional, time-dependent flow fields in the process of laminar-turbulent transition of a flat-plate boundary layer.

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PURDUE UNIVERSITY, Department of Agricultural Engineering, West Lafayette, Ind. 47907. Dr. G. W. Isaacs, Department Head.

129-03808-830-05

PREDICTING RUNOFF AND GROSS EROSION FROM FARMLAND AND DISTURBED AREAS (also see Agri. Research Serv., North Central Region, Project 04275).

(*b*) Agricultural Research Service, USDA; Agricultural Experiment Station, Purdue University.
(*c*) Dr. G. R. Foster.
(*d*) Experimental investigation; basic and applied research.
(*e*) The relationships of rainfall, soil, topographic, land-use, and management parameters to runoff and soil erosion are evaluated from field-plot and laboratory data, and the mechanics of soil erosion by water are studied as a basis for mathematically simulating the soil erosion process.
(*g*) Effects of slope concavity, runoff rate, entrained sediment, and particle size on the deposition of noncohesive particles by overland flow were investigated. One study with rills showed that a critical discharge exists below which little erosion occurs, the erosion rate varies linearly with discharge minus the critical discharge, a nonerodible layer decreases erosion but widens the rills, and, while tillage increases rill erosion, buried pieces of large crop residue greatly reduce rill erosion. A national erosion conference (proceedings available) was held at Purdue University in May 1976 to discuss the extent of erosion problems, application of the Universal Soil Loss Equation, and contribution to water pollution by soil erosion. The USDA Agricultural Handbook No. 282 for estimating field soil loss is currently being revised.
(*h*) **Hydraulics of Flow in a Rill,** G. R. Foster, *Ph.D. Thesis*, Purdue Univ., 1975.
New Developments in Estimating Water Erosion, W. H. Wischmeier, *Proc. 29th Ann. Mtg. Soil Cons. Soc. Amer.*, pp. 179-185, 1974.
Effect of Flow Rate and Canopy on Rill Erosion, L. D. Meyer, G. R. Foster, S. Miklov, *Trans. Amer. Soc. Agric. Engrs.* **18**, 5, pp. 905-911, 1975.
Erosion Modeling on a Watershed, C. A. Onstad, G. R. Foster, *Trans. Amer. Soc. Agric. Engrs.* **18**, 2, pp. 288-292, 1975.
Control of Water Pollution from Cropland, B. A. Stewart, D. A. Woolhiser, W. H. Wischmeier, J. H. Caro, M. H. Frere, *ARS-H-51, Agri. Research Serv., USDA, Vol. I and II*, 1975.
Use and Misuses of the Universal Soil Loss Equation, W. H. Wischmeier, *J. Soil and Water Cons.* **31**, 1, pp. 5-9, 1976.

129-07584-820-61

IMPROVING THE QUALITY OF LAND AND WATER RESOURCES

(*b*) Agricultural Experiment Station, Purdue University; U.S. Environmental Protection Agency.
(*c*) Dr. E. J. Monke.
(*d*) Experimental, theoretical, field investigation, applied research.
(*e*) Study the dynamics of water and pollutant movement in soil, to evaluate the effects of subsurface drainage on crop production, to evaluate erosion and related chemical transport from agricultural soils, and to simulate the effects of land use on sedimentation and related-pollution of streams and lakes.
(*g*) The effect of land treatment on the movement of sediment and chemicals from a 4950 ha agricultural watershed is being studied. Best management practices for controlling the offsite effects of erosion are conservation tillage which provides protection of the soil surface over critical periods of the year and parallel, tile-outlet terraces or small detention reservoirs which temporarily store runoff thus providing time for sediment deposition to occur. Soils with improved tilth were shown to substantially reduce both sediment and nutrient losses from land and to alter the composition of the transported materials. A distributed watershed model was developed as an aid for quantifying sediment yield reductions from specific land use treatments. The model will also be useful as a planning tool for controlling nonpoint source pollution of water resources.
(*h*) **Movement of Pollutant Phosphorus in Unsaturated Soil,** E. J. Monke, E. D. Millette, L. F. Huggins, *Tech. Rept. No. 46*, Water Resources Research Center, Purdue Univ., 1974.
Sediment Contributions to the Maumee River, E. J. Monke, D. B. Beasley, A. B. Bottcher, *EPA-905/9-75-007, Proc. Non-Point Pollution Seminar*, pp. 71-85, Reg. V, USEPA, Chicago, 1975.
Land Use and Sediment Yields in the Black Creek Watershed, E. J. Monke, *Proc. Workshop on Non-Point Sources of Water Pollution*, pp. 70-80, Water Resources Research Center, Purdue Univ., 1976.
Sediment Yield from an Agricultural Watershed into the Maumee River, E. J. Monke, *EPA-905/9-76-005, Proc. Best Management Practices for NPS Pollution Control*, pp. 131-140, Reg. V, USEPA, Chicago, 1976.
Runoff, Erosion, and Nutrient Movement from Interrill Areas, E. J. Monke, H. J. Marelli, L. D. Meyer, J. F. DeJong, *Trans. Amer. Soc. Agric. Engrs.* **20**, 1, pp. 58-61, 1977.

129-07585-810-33

CHARACTERIZATION OF THE HYDROLOGY OF SMALL WATERSHEDS

(*b*) Agricultural Experiment Station, Purdue University; Office of Water Research and Technology, USDI; U.S. Environmental Protection Agency.
(*c*) Dr. L. F. Huggins.
(*d*) Experimental, basic, applied, design.
(*e*) Develop an analytical method to accurately describe the hydrologic response of natural watersheds to real or hypothetical storms independent of gaged records for a watershed.
(*g*) Emphasis is being placed on the development of a distributed parameter watershed model which is capable of simulating both the hydrology and nonpoint source pollution process at all points throughout a complex area. The primary nonpoint pollution process receiving attention is soil erosion/transport and its associated chemicals.
(*h*) **Simulation of the Hydrology of Ungaged Watersheds,** L. F. Huggins, J. R. Burney, P. S. Kundu, E. J. Monke, *Tech. Rept. No. 38*, Water Resources Research Center, Purdue Univ., 1973.
Computer Monitoring of Environmental Conditions in a Watershed, L. F. Huggins, *EPA-905/9-75-007, Proc. Non-Point Source Pollution Seminar*, pp. 151-161, Reg. V, USEPA, Chicago, 1975.
Hydrologic Simulation Using Distributed Parameters, L. F. Huggins, T. H. Podmore, C. F. Hood, *Tech. Rept. No. 82*, Water Resources Research Center, Purdue Univ., 1976.
A Systematic Approach to Data Reduction Using GASP IV, G. A. Wong, S. J. Mahler, J. R. Barrett, L. F. Huggins, *Proc. Winter Simulation Conf.*, pp. 403-410, 1976.

Environmental Data Acquisition and Real-Time Computers, L. F. Huggins, S. J. Mahler, *EPA-905/9-76-005*, *Proc. Best Management Practices for NPS Pollution Control*, pp. 164-170, Reg. V, USEPA, Chicago, 1976.

PURDUE UNIVERSITY, School of Chemical Engineering, West Lafayette, Ind. 47907. Professor Lowell B. Koppel, Head.

131-07592-130-00

DRAG REDUCTION IN TWO-PHASE FLOW

(*c*) Professor R. A. Greenkorn or Professor D. P. Kessler.
(*d*) Experimental, theoretical, basic; M.S. and Ph.D. theses.
(*e*) To measure and correlate drag coefficients in tubes, fittings, pumps, etc., in the laminar, transitional, and turbulent regimes for the annular flow of two liquids plus a suspended solid phase. The outer liquid will be viscoelastic. Experiments will be run in flow slip at Reynolds number up to 100,000. Pressure drop measurements, velocity profiles, and visual observations will be used to postulate mechanisms for such flow and derive predicting equations. The data will be correlated according to these equations.
(*h*) **A Study of Liquid-Liquid Flow in Pipes**, W. P. Garten, *M.S. Thesis*, available Purdue Univ. Library.
A Study of Annular Two-Phase Oil-Water Flow in Conduits, M. H. Stein, *M.S. Thesis*, available Purdue Univ. Library.

131-08242-020-00

STATISTICAL AND PHENOMENOLOGICAL MODELS OF TURBULENT ENERGY EQUATION

(*c*) R. N. Houze, Assoc. Professor.
(*d*) Theoretical; basic.
(*e*) Solutions of the turbulent energy equation are being obtained utilizing various statistical and phenomenological models for the turbulent stresses. Solutions are being compared with available published data. Methods are to be extended to free surface flows, with aim of predicting turbulence characteristics pertinent to interphase transport processes.

131-08243-130-00

FREE BOUNDARY TURBULENCE

(*b*) National Science Foundation.
(*c*) Professor T. G. Theofanous; Assoc. Professor R. N. Houze.
(*d*) Experimental, theoretical, basic; M. S. and Ph.D. theses.
(*e*) A two-dimensional fully developed, stratified, gas liquid flow system is being studied with special emphasis on the turbulent characteristics of the liquid phase in the immediate vicinity of the interface.
(*h*) **Horizontal, Stratified, Gas-Liquid Flow: The Interfacial Region**, T. G. Theofanous, R. N. Houze, D. M. Johns, *15th Natl. Heat Transfer Conf.*, San Francisco, Calif., Aug. 1976.
Structure of Free Boundary Turbulence with Interphase Mass Transport, T. G. Theofanous, R. N. Houze, L. K. Brumfield, D. M. Johns, *PCHE 76-1*, Two-Phase Flow and Mass Transfer Lab., School of Chemical Engrg., Purdue University.

131-08244-130-00

TURBULENT TRANSPORT AT FREE INTERFACES

(*b*) National Science Foundation.
(*c*) Professor T. G. Theofanous; Assoc. Professor R. N. Houze.
(*d*) Experimental, theoretical, basic; Ph.D. theses.
(*e*) Statistical and eddy turbulence models are being devised to elucidate the mechanism of the fluid mechanical interaction of bulk turbulence and a free interface and hence arrive to a quantitative description of the mass transfer characteristics of the interface.
(*h*) **On the Prediction of Heat Transfer Across Turbulent Liquid Films**, L. K. Brumfield, T. G. Theofanous, *J. Heat Transfer* **98**, 3, Aug. 1976.
Turbulent Mass Transfer at Free, Gas-Liquid Interfaces, with Applications to Open-Channel, Bubble and Jet Flows, T. G. Theofanous, R. N. Houze, L. K. Brumfield, *Intl. J. Heat Mass Transfer* **19**, pp. 613-624, 1976.
Turbulent Mass Transfer at Free, Gas-Liquid Interfaces with Applications to Film Flows, L. K. Brumfield, R. N. Houze, T. G. Theofanous, *Intl. J. Heat Mass Transfer* **18**, pp. 1077-1081, 1975.
Turbulent Mass Transfer in Jet Flow and Bubble Flow: A Reappraisal of Levich's Theory, L. K. Brumfield, T. G. Theafanous, *AIChE J.* **22**, 3, May 1976.

131-09839-820-54

THE ENVIRONMENTAL FLOW OF TRACE METALS

(*b*) National Science Foundation.
(*c*) Professor R. A. Greenkorn.
(*d*) Experimental, theoretical, applied; M.S. and Ph.D. theses.
(*e*) Specific objectives are to estimate the flow properties of a groundwater reservoir; construct a resistance analog of the aquifer to study water movement; program necessary calculations to trace metals movement; design and construct an observation well system; sample aquifer sand and water at various depths to determine trace metals present; use the well system to confirm estimate of aquifer properties by analysis of the pumping characteristics of the well system; develop the hydrology for the aquifer; determine the movement of the trace metals using the calculations obtained to trace metals movement and the hydrology for the aquifer; monitor the system by measurements in the wells and by calculation of fluid movement.
(*h*) **Exploratory Study of the Flow Characteristic and the Movement of Trace Metals in the East Chicago Cadmium Project Test Site**, A. Mathews, *M.S. Thesis (1975)*, available Purdue Univ. Library.

131-09840-820-00

THE EFFECT OF PORE STRUCTURE ON THE SATURATION OF FLUIDS IN POROUS MEDIA

(*b*) Purdue Research Foundation.
(*c*) Professors R. A. Greenkorn and D. P. Kessler.
(*d*) Experimental, theoretical, basic; M.S. and Ph.D. theses.
(*e*) A study of the effect on nonuniformity on saturation of a fluid in a porous medium to determine more precisely the relationship between dimensionless capillary pressure and pore size distribution. In most recovery processes the necessary condition for moving oil by flooding is that a pressure drop be available to move oil. In the tertiary processes using surface active materials more of the pressure drop is available to move oil from the smaller pores and less is required to overcome interfacial tensions. A sufficiency condition to make this method applicable is that the oil be present, that is, we must have knowledge about the volume of small pores which contain oil following a conventional recovery operation. This implies that in order to understand and design recovery operations a more precise knowledge of capillary pressure-saturation behavior must be known.
(*h*) **An Experimental Investigation of Capillary Pressure Behavior as a Function of Pore Size Distribution**, M. F. Smith, *M.S. Thesis*, 1976, available Purdue Univ. Library.

PURDUE UNIVERSITY, School of Mechanical Engineering, West Lafayette, Ind., 47907. Professor R. Viskanta.

132-09841-440-33

LABORATORY SIMULATION OF MIXING IN THERMALLY STRATIFIED, HEATED LAKES, RESERVOIRS AND PONDS

(*b*) Office of Water Research and Technology.
(*d*) Experimental and theoretical.
(*e*) Internal mixing processes play a critical role in the convective and dispersive transport of oxygen, material pollutants, nutrients and biota, in the dispersal of thermal effluents, and in the internal energy transport for establishing the thermal structure (temperature distribution) in the water. The specific objective of the research program is to investigate the internal mixing and energy transport processes in thermally stratified, heated and/or cooled water by performing laboratory experiments under carefully controlled environment simulating as closely as possible the conditions existing in stagnant natural waters such as lakes, reservoirs, and ponds. The internal mixing and energy transport in water will be simulated in a tank filled with water. The water will be first stratified by irradiating it from "solar heaters" and then cooled from the free surface. The unsteady temperature distribution in the water will be measured with a Mach-Zehnder interferometer. The internal mixing and flow field in the water will be visualized and measured using tracer techniques. The experimental data will be analyzed with the view of obtaining vertical mixing (turbulent eddy diffusion) coefficients and local (molecular and turbulent diffusive as well as convective) energy fluxes. In the analytical phase of the investigation, a mathematical model will be developed to predict internal free convective flow and energy transfer in a stratified layer of water resulting from cooling and/or heating at the surface.
(*h*) **Laboratory Study of Unsteady Energy Transfer in Surface Layers of Stratified Water,** R. Viskanta, J. R. Parkin, *Water Resources Research* **12**, 6, pp. 1277-1285, 1976.
A Study of Cooling Initially Uniform and Thermally Stratified Layers of Water, M. Behnia, *M.S. Thesis*, Purdue Univ., Dec. 1976; obtainable Purdue Univ. Library.

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PURDUE UNIVERSITY, School of Nuclear Engineering, West Lafayette, Ind. 47907. Paul S. Lykoudis, Professor and Head.

133-10087-110-54

THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF SINGLE-PHASE AND TWO-PHASE LIQUID METAL FLOWS IN THE PRESENCE OF MAGNETIC FIELDS

(*b*) National Science Foundation.
(*d*) Theoretical and experimental; basic research; M.S. and Ph.D. theses.
(*e*) The Magneto-Fluid-Mechanic Facility at Purdue University consists of isothermal and heat transfer loops in which the working medium is mercury. 300 gallons per minute of mercury are pumped through test sections simulating turbulent Hartmann channel flow. An electromagnet with pole faces 1′×50′ provides a magnetic field of 1.5 Tesla at a gap of 3 inches. Hot film anemometry is used to probe the flow. The range of Hartmann and Reynolds numbers is 1500 and 500,000, respectively. Nucleate boiling in liquid metals is being studied in an experimental apparatus consisting of a horizontal heated surface in the presence of a horizontal magnetic field. The boiler has a capability of 300 kw/m^2 heat flux. Platinum resistance thermometers are used for the bulk and surface temperature measurements. At the present time water has been used in our nucleate boiling experiment for testing purposes. We are in the process of proceeding with our experiments with mercury and then potassium. The work is relevant for liquid metal MHD power generation and also proposed blankets of fusion reactors.
(*g*) Prandtl's mixing length theory has been extended to account for the damping of turbulence due to the presence of the magnetic field. The damping function is equal to exp $(AM^2/Re^{1.75})$. The constant A depends on the geometry of the magnetic field (aligned or perpendicular). This function was used to predict the skin friction and u′v′ data for two-dimensional channel Hartmann flows with vertical field and found to be in agreement with experiments performed in our laboratory.
A semi-empirical theory was also developed for the ratio of eddy diffusivities for heat and momentum transfer accounting for the magnetic field. Heat transfer measurements in pipes with aligned fields were found to agree with theoretical predictions.
The growth of the bubble in the presence of a magnetic field was investigated. The work reveals the existence of a new nondimensional number which physically represents the ratio of the ponderomotive forces over pressure forces computed on the basis of length-scale and time related to the coefficient of thermal diffusion. It was found that for a spherical magnetic field, growth of the bubble remains parabolic in time but the rate of growth is slower. Heat-transfer estimates indicate that heat transfer is reduced in the presence of magnetic fields. This reduction is more substantial for potassium than it is for mercury. The assumption of spherical symmetry for the field has been relaxed.
(*h*) **Liquid-Metal Heat Transfer in Pipes with Aligned Magnetic Fields,** P. S. Lykoudis, M. Andelman, *Trans. Amer. Nuclear Soc. 1975 Ann. Mtg.* **21**, pp. 36-37, June 8-13, 1975.
The Effect of Liquid Inertia on Bubble Growth in the Presence of a Magnetic Field, P. S. Lykoudis, L. Y. Wagner, *Paper No. AIChE-37, Proc. ASME, AIChE 16th Natl. Heat Transfer Conf.*, St. Louis, Mo., Aug. 8-11, 1976.
Bubble Growth in the Presence of a Magnetic Field, P. S. Lykoudis, *Intl. J. Heat Mass Transfer* **19**, pp. 1357-1362, 1976.
Short Description of Current Work in the MFM Laboratory of Purdue University, P. S. Lykoudis, from **MHD-Flows and Turbulence,** H. Branover, ed., *Proc. Bat-Sheva Intl. Seminar*, Beersheva, Israel, pp. 103-118, Mar. 17-20, 1975.

133-10088-130-55

TRANSIENT DEVELOPMENT OF TWO-DIMENSIONAL TWO-PHASE FLOW BOILING

(*b*) Nuclear Regulatory Commission.
(*c*) Professor T. G. Theofanous.
(*d*) Theoretical; applied, research; M.S. and Ph.D. theses.
(*e*) Certain accidental transients in Liquid Metal Fast Breeder Reactors may lead to liquid sodium boiling which is two-dimensional in character. The transient development of this coolant boiling is important in determining the resulting neutronic feedback and resulting power transient. The work involves the numerical modeling of this process. The unique aspect of the work is in taking the view that the boiling flow process within a tight matrix of fuel rods can be modeled as one in a porous body.
(*g*) Current results indicate that significant differences as far as reactor response is concerned may be attributed to the two-dimensional nature of actual boiling versus the previously employed simplified treatment of one-dimensional boiling.
(*h*) **A Numerical Simulation of the Two-Dimensional Boiling (Voiding) in LMFBR Subassemblies,** C. Miao, T. G. Theofanous, *Proc. Intl. Mtg. Fast Reactor Safety and Related Physics*, Chicago, Ill., Oct. 1976.

133-10089-340-55

PROPAGATION OF THERMAL EXPLOSIONS

(*b*) Nuclear Regulatory Commission.
(*c*) Professor T. G. Theofanous.
(*d*) Experimental, theoretical; basic; Ph.D. thesis.

254-330 O - 78 - 9

(*e*) Development of hydrodynamic-in-origin mechanisms for rapid and extensive fragmentation of one liquid into another. Effects of shock waves and collapse of vapor blankets are of particular interest. Such fragmentation is the crucial propagation step in vapor explosions and a better understanding will help determine the likelihood of such explosions for reactor accident conditions.

133-10090-340-55

STABILITY CHARACTERISTICS OF VOLUMETRICALLY HEATED MULTICOMPONENT BOILING POOLS

(*b*) Nuclear Regulatory Commission.
(*c*) Professor T. G. Theofanous.
(*d*) Experimental, theoretical; basic; Ph.D. thesis.
(*e*) This problem is relevant to the hypothetical occurrence of a core meltdown accident of a Liquid Metal Fast Breeder Reactor. The stability characteristics of such fuel pools would determine the power transient and total energy deposition during the accident. The work involves model experiments (using a microwave facility) and theoretical studies.

133-10091-110-54

TURBULENT STRUCTURE IN NONISOTHERMAL LIQUID METAL

(*b*) National Science Foundation.
(*c*) Professor Alexander Sesonske.
(*d*) Experimental, theoretical, basic; M.S. and Ph.D. theses.
(*e*) To measure the statistical turbulent behavior of the velocity and temperature fields in mercury pipe flow; to use turbulent structure parameters, including turbulent heat flux, to verify and develop heat transport predictive models; and to explore how the pipe flow results might be extended to complex geometries. Turbulence measurements are being made, using hot-film anemometry, in a flexible heat transfer facility provided with various test section flow and temperature traversing arrangements.
(*g*) Axial and radial turbulent heat fluxes, as well as other structure parameters, were derived from hot-film measurements using digital time-series analysis. These results provide a basis for the analysis and development of transport predictive models. In addition, the eddy diffusivity concept appears to have a useful role when based on turbulence length scales.
(*h*) **Turbulent Structure of Isothermal and Nonisothermal Liquid Metal Pipe Flow,** L. E. Hochaeiter, A. Sesonske, *Intl. J. Heat and Mass Transfer* **17,** p. 113, 1974.
Non-Isothermal Mercury Pipe Flow Turbulent Characteristics, T. W. Flaherty, L. L. Eyler, A. Sesonske, *Proc. 4th Biennial Symp. Turbulence in Liquids,* Univ. of Mo., Rolla, Mo., 1975.
A Predictive Technique for Temperature and Eddy Diffusivity Distributions in Liquid Metal Turbulent Pipe Flow, G. A. Klein, A. Sesonske, *Proc. 1976 Natl. Heat Transfer Conf.,* 1976.
Turbulent Heat Fluxes in Liquid-Metal Channel Flow–Models and Experiments, L. L. Eyler, A. Sesonske, *Trans. Am. Nucl. Soc.* **24,** p. 368, 1976.
Space-Time Correlations of Temperature in Turbulent Mercury Pipe Flow, S. C. Caruso, *M.S. Thesis,* available Purdue University.

THE RAND CORPORATION, Department of Physical Sciences, 1700 Main Street, Santa Monica, Calif. 90406. Dr. E. C. Gritton, Department Head. (Publications may be purchased.)

134-08952-400-33

DEVELOPMENT OF A THREE-DIMENSIONAL MODEL FOR ESTUARIES AND COASTAL SEAS

(*b*) Department of the Interior, Office of Water Research and Technology.
(*c*) Dr. J. J. Leendertse.
(*d*) Experimental and theoretical; applied research and development.
(*e*) Develop a finite difference model which can be used to compute the flow in estuaries with nonisotropic density. The model is intended to be used in engineering and scientific investigations of estuaries with complicated bathymetry and flow patterns.
(*h*) **A Three-Dimensional Model for Estuaries and Coastal Seas: Volume I, Principles of Computation,** J. J. Leendertse, R. C. Alexander, S.-K. Liu, *R-1417-OWRR,* Dec. 1973.
A Three-Dimensional Model for Estuaries and Coastal Seas: Volume II, Aspects of Computation, The Rand Corporation, *R-1764-OWRT,* June 1975.
A Three-Dimensional Model for Estuaries and Coastal Seas: Volume III, The Interim Program, The Rand Coporation, *R-1884-OWRT,* Oct. 1975.

134-09908-010-18

LAMINAR FLOW HYDRODYNAMICS

(*b*) Defense Advanced Research Projects Agency.
(*c*) Dr. E. C. Gritton.
(*d*) Theoretical; basic and applied.
(*e*) With the purpose of obtaining extended regions of laminar flow and accompanying low hydrodynamic drag, this is an investigation of the effects of pressure gradient, heat transfer, and other means of boundary-layer control on the development, stability, and transition of water boundary layers.
(*g*) Analytical and numerical studies have been made of water boundary layers with combined pressure gradient and heat transfer. The results provide the basis for predicting the effects of flow geometry and heat transfer on hydrodynamic performance.
(*h*) **Controlling the Separation of Laminar Boundary Layers in Water: Heating and Suction,** J. Aroesty, S. A. Berger, The Rand Corporation, *R-1789-ARPA,* Sept. 1975.
On the Effects of Wall Temperature and Suction on Laminar Boundary-Layer Stability, W. S. King, The Rand Corporation, *R-1863-ARPA,* Apr. 1976.
Buoyancy Cross-Flow Effects on the Boundary Layer of a Heated Horizontal Cylinder, L. S. Yao, I. Catton, The Rand Corporation, *R-1907-ARPA,* Apr. 1976; also *J. Heat Trans., Trans. ASME* **97,** Series C, pp. 122-124, 1977.
The Buoyancy and Variable Viscosity Effects on a Water Boundary Layer Along a Heated Longitudinal Horizontal Cylinder, S. A. Berger, J. Aroesty, The Rand Corporation, *R-1966-ARPA,* Feb. 1977.
e^9: Stability Theory and Boundary-Layer Transition, J. Aroesty, The Rand Corporation, *R-1898-ARPA,* Feb. 1977.

134-09909-870-52

ATMOSPHERIC EFFECTS OF LARGE POWER-GENERATING FACILITIES

(*b*) Energy Research and Development Administration.
(*c*) Dr. L. Randall Koenig.
(*d*) Theoretical: applied research.
(*e*) Investigate the possibility that rejection to the atmosphere of large amounts of waste heat can induce the development of large-scale convective cloudiness and precipitation. Two approaches are used, the study of natural and industrial analogs, and development of hydrodynamical atmospheric models.
(*g*) Time lapse photography shows refineries to be good analogs. Satellite imagery is useful. A two-dimensional numerical cloud model simulates an observed refinery cloud well, pointing to its use for power facilities with larger heat rejection.
(*h*) **Difference in Atmospheric Convection Caused by Waste Energy Rejected in the Forms of Sensible and Latent Heats,** L. R. Koenig, F. W. Murray, P. M. Tag, submitted to *Atmospheric Environment.*

Numerical Simulation of an Industrial Cumulus and Comparison with Observations, F. W. Murray, L. R. Koenig, P. M. Tag, to be submitted to *J. Applied Meteorology.*

134-09910-270-40

MATHEMATICAL MODELS FOR STUDYING SICKLE CELL DISEASE

(*b*) National Institutes of Health.
(*c*) Dr. William S. King.
(*d*) Theoretical.
(*e*) Develop mathematical models and computer simulations to examine the interplay among the fluid mechanics of the microcirculatory system, blood chemistry, oxygen transport phenomena, and red cell sickling. Particular emphases are placed on modeling the blockage of capillaries by sickled red blood cells. The ultimate goal is to simulate mathematically a vascular occlusive crisis.
(*g*) Analytical models have been developed to study the physicochemical aspect of the sickling process as well as the kinetics of sickling. These models are being incorporated into our capillary flow models.

RENSSELAER POLYTECHNIC INSTITUTE, Department of Mathematical Sciences, Troy, N. Y. 12181. Dr. Richard C. DiPrima, Department Chairman.

135-06772-000-20

VISCOUS FLOW STABILITY

(*b*) Office of Naval Research.
(*c*) Professors R. C. DiPrima, D. A. Drew.
(*d*) Theoretical; basic research.
(*e*) Stability and two-phase effects are studied in an effort to achieve basic understanding of fluid flows which have importance in applications.
(*g*) Work in nonlinear hydrodynamic stability has centered on the calculation of Taylor-vortex flow between eccentric rotating cylinders so as to determine the torque and force on the inner cylinder which is of interest in lubrication theory; the calculation of torque and amplification rates for Taylor vortices between concentric cylinders; and the stability of spatially periodic secondary flows for slightly supercritical conditions. In lubrication theory, interest has centered on asymptotic analysis of the nonlinear Reynolds equation for slider gas bearings operating at very high bearing numbers when the film thickness has a discontinuous slope at a point. It is shown that the derivative of the pressure has a boundary layer at the point of discontinuity. Results are given for taper-flat and taper-taper slider bearings. Investigations in two-phase flows have followed two central themes. First, studies have been made to determine the appropriate form for the interphase force in a particle-fluid mixture, and its effect on fundamental flows. They include studies of the effects of the pressure gradient and lift forces on the particulate phase and the mixture Reynolds stresses. Second, studies have been made of the effect of turbulence in two-phase flows. These include a calculation of the concentration and velocity profiles in sediment flow; a study of the role of dissipation by interfacial drag in a turbulent flow, and its relation to drag reduction. Also see 135-06773-000-14.
(*h*) **The Nonlinear Calculation of Taylor-Vortex Flow Between Eccentric Rotating Cylinders,** R. C. DiPrima, J. T. Stuart, *J. Fluid Mechanics* **67**, pp. 85-111, 1975.
Asymptotic Methods for an Infinite Slider Bearing with a Discontinuity in Film Slope, J. A. Schmitt, R. C. DiPrima, *J. Lubrication Technology* **98**, pp. 446-452, 1976.
Low Concentration Two-Phase Flow Near a Stagnation Point, D. A. Drew, *Physics of Fluids* **17**, pp. 1688-1691, 1974.
Lift-Generated Instability of the Plane Couette Flow of a Particle-Fluid Mixture, D. A. Drew, *Physics of Fluids* **18**, pp. 935-938, 1975.
Macroscopic Streamline Integral Relations for Two-Phase Flows, D. A. Drew, *J. Applied Mechanics* **42E**, pp. 766-770, 1975.
Two-Phase Flows: Constitutive Equations for Lift and Brownian Motion and Some Basic Flows, D. A. Drew, *Archive for Rational Mechanics and Analysis* **62**, pp. 149-163, 1976.
Production and Dissipation of Energy in the Turbulent Flow of a Particle-Fluid Mixture, with Some Results on Drag Reduction, D. A. Drew, *J. Applied Mechanics* **43E**, pp. 543-547, 1976.
Effect of the Lift Force on the Stability of Uniform Fluidization, D. A. Drew, *Physics of Fluids* **19**, pp. 1716-1720, 1976.

135-06773-000-14

ANALYSIS OF NONLINEAR PROBLEMS IN FLUID MECHANICS

(*b*) U.S. Army Research Office.
(*c*) Professors R. C. DiPrima, L. A. Segel.
(*d*) Theoretical; basic research.
(*e*) Investigation of nonlinear mathematical problems arising in fluid mechanics (particularly stability problems), chemically-oriented motions of organisms, and pattern formation.
(*g*) Work has centered on 1) the calculation of the Taylor-vortex flow between eccentric rotating cylinders so as to determine the torque and force on the inner cylinder which is of interest in lubrication theory; 2) the effect of finite amplitude on the decaying torsional oscillations of a sphere and a disk–a problem of interest in viscometry; and 3) extension of basic principles of continuum physics to permit mathematical investigation of biological phenomena such as spatio-temporal pattern formation. For 3) random dispersal in predator-prey problems is modeled by diffusion-like terms in both discrete and continuous situations. It is shown that under some circumstances uniform conditions will be succeeded by a new steady state wherein predator and prey are more concentrated in certain regions.
(*h*) **The Nonlinear Calculation of Taylor-Vortex Flow between Eccentric Rotating Cylinders,** R. C. DiPrima, J. T. Stuart, *J. Fluid Mechanics* **67**, pp. 85-111, 1975.
A Nonlinear Model for Double-Diffusive Convection, W. L. Siegmann, L. A. Rubenfeld, *SIAM J. Applied Mathematics* **29**, pp. 540-557, 1975.
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On the Relation between the Local Interaction of Cells and Their Global Transformation, L. A. Segel, *Theoretical Physics and Biology, Proc. 4th Intl. Conf.*, Versailles 1973, Amsterdam: North Holland Press, 1976.
Application of Nonlinear Stability Theory to the Study of the Effects of Diffusion on Predator-Prey Interactions, L. A. Segel, S. A. Levin, *Topics in Statistical Mechanics and Biophysics, American Institute of Physics AIP Conf. Proc.* **27**, 1976.
Incorporation of Receptor Kinetics into a Model for Bacterial Chemotaxis, L. A. Segel, *J. Theoretical Biology* **57**, pp. 23-42, 1976.
Effect of Secondary Flow on the Decaying Torsional Oscillations of a Sphere and a Plane, R. C. DiPrima, N. Liron, *Physics of Fluids* **19**, pp. 1450-1458, 1976.
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RENSSELAER POLYTECHNIC INSTITUTE, Department of Mechanical Engineering, Aeronautical Engineering and Mechanics, Jonsson Laboratory, Troy, N.Y. 12181. Henry A. Scarton, Assistant Professor of Mechanical Engineering.

136-09653-270-00

BIOMECHANICS OF KOROTKOFF SOUND PRODUCTION, VALSALVA MANEUVER INDUCED VENA CAVA FLUTTER, URETER VALVE FLUTTER, AND OTHER RELATED PHENOMENA

(*e*) A self-excited large deformation elastic snap-through streaming viscous fluid relaxation oscillation of the brachial artery, vena cava, and ureter have been experimentally shown to be produced as a result of a condition where the external pressure exceeds the internal static tube pressure. In the brachial artery, these oscillations are responsible for the production of Korotkoff sounds which are used in the auscultatory method of blood pressure determination; in the vena cava, these oscillations are an unwanted and dangerous source of viscous pressure drop; in the ureter, these oscillations serve the useful purpose of inhibiting backflow into the kidney from the bladder during bladder expulsion. Similar phenomena also occur in the cochlea of the inner ear. In all of these applications it is desirable to know the precise parametric nature of the oscillation. To date basic analysis done at RPI are being extended in order to further predict oscillation characteristics experimentally measured in our laboratory. Further analytical and experimental work are now being carried out to characterize the effect of constriction induced vortex shedding and wall flutter effects.

136-09654-270-00

BIOMECHANICS OF AORTIC ATHEROMA AND AORTIC COMMON ILIAC BIFURCATION

(*e*) The spatial distribution of early atheroma has been shown experimentally to be coincident with those regions of the curved aortic wall where the velocity gradient, and hence wall shear and mass transport, is low; for the proximal ascending aorta, this region is the inside wall closest to the center of aortic curvature. Independent experiments have shown that the entry aortic fluid core velocity distal to the left ventricle behaves as if it were inviscid so that it varies as the reciprocal of the tube principal radius of curvature and hence is paradoxically lower near the outside than near the inside curved wall. The presence of a centrifugally induced secondary flow is then required in order to thin the outer wall viscous boundary layer and consequently steepen the radial velocity gradient to produce an increase in outer wall mass transfer. Both experimental flow visualization techniques and the analytical determination of this three-dimensional boundary layer in the entry region of the proximal ascending aorta show the existence of two counterrotating trapped inner wall vortices which are coincident with regions of wall streaking and ulceration. In addition to observing these lesions in the aortic arch in cadavers we have also observed similar lesions in the aorto-common iliac region. We attribute this latter phenomena to observed assymmetry of the cross-section leading to different radii of curvature for the right and left side of the bifurcation. This difference and the associated difference in centripetal acceleration is responsible for flow separation in the section of larger radius of curvature. Additional detailed studies are being performed in our full scale aortic test chamber. Attempts are being made to minimize the effect of reversed flow by variation of reversed flow through alteration of local anatomic geometry.

136-09655-030-00

FLOW-INDUCED VIBRATIONS IN NUCLEAR FUEL PLATE ASSEMBLIES

(*c*) Henry A. Scarton.

(*e*) Flow-induced stability and collapse phenomena caused by mechanisms similar to that in 09653 above, also occur in nuclear fuel rod bundles and reactor heat exchanger plating. These oscillations and buckling phenomena are an unwanted and dangerous effect that must be properly understood in order that proper preventative design techniques can be employed. Analytical treatments of the problem are being undertaken to consider the role of local entrance effects.

136-09656-600-00

SIGNAL SIMULATION OF STEADY PERIODIC WAVES, ACOUSTIC TRANSIENTS, AND ACOUSTIC STREAMING IN FLUIDIC DELAY LINES

(*e*) In recent years much attention has been focused on the propagation of small amplitude steady-periodic pressure waves through fluids confined in rigid tubes. Although a problem long of intrinsic interest to acousticians, most of the recent research has been spurred on by technological developments in fluid transmission lines and acoustic delay lines, and the desire for better mathematical models of biological flows, particularly arterial blood flow. The effects of viscosity cannot be ignored in these applications, in contrast to the customary acoustic approach. But in the few instances where viscosity has been considered, the analyses have been confined to simplified dynamic models (e.g., quasi-steady and/or plane pressure waves have been assumed), or else incomplete. Analytic studies are being employed to study steady-periodic signal simulation, acoustic transients, and acoustic streaming in viscous compressible liquid-filled rigid delay lines.

136-09842-630-70

QUIET AIR TOOL DEVELOPMENT

(*b*) General Electric Company.
(*e*) Acoustic and noise control research studies are being pursued with specific application to quieting excessively noisy air tools. Various experimental and theoretical considerations are being studied so as to lower acoustic emissions below the anticipated OSHA noise requirement of 85dBA sound pressure level exposure for an eight-hour day.

136-09843-140-54

STUDIES OF NUCLEATE BOILING ACOUSTIC EMISSION

(*e*) Analytical and experimental research is being conducted into the fundamental mechanisms of nucleate boiling as they relate to the far field acoustic pressure. The motivation for the work lies in being able to detect and characterize the existence of unwanted boiling of the liquid sodium coolant in a Liquid Metal Fast Breeder Reactor (LMFBR). The phases of boiling studied are nucleation, departure, steady-state free and forced vibration, and cavitational collapse and rebound.

136-09844-620-54

STUDIES OF STICK SLIP INDUCED ACOUSTIC EMISSION

(*b*) National Science Foundation.
(*e*) The fundamental mechanism associated with rolling contact involves a transition in an annular slip contact region during which there is small scale relative motion at the interface. Similarly rapid thermal excursions in structures such as the core of the LMFBR (See 09843) have been shown to produce thermally induced stick slip events between the various mating structural elements. Both scenerios have similar governing physical mechanisms relating to various aspects of the contact stress problem. Both theoretical and experimental work has been conducted to further the understanding of this process.

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UNIVERSITY OF ROCHESTER, Department of Mechanical and Aerospace Sciences, Rochester, N.Y. 14627. Professor Alfred Clark, Jr., Chairman.

137-09958-440-54

NUMERICAL MODELING OF STEADY WIND-DRIVEN CURRENTS IN LAKE ONTARIO

(*b*) National Science Foundation and Office of Naval Research.
(*c*) John H. Thomas, Assoc. Professor.
(*d*) Theoretical investigation; basic research; associated field program.
(*e*) A fully three-dimensional model of wind-driven circulation in Lake Ontario under winter conditions, based on shallow-water theory, has been developed and tested against observations. Both the basic theory and the numerical model have been extended to include a depth-dependent eddy viscosity.
(*f*) Completed.
(*g*) See (h).
(*h*) **Numerical Calculation of Steady Wind-Driven Currents in Lake Ontario and the Rochester Embayment,** G. Bonham-Carter, J. H. Thomas, *Proc. 16th Conf. Great Lakes Res.*, Intl. Assoc. Great Lakes Res., pp. 640-662, 1973.
A Theory of Steady Wind-Driven Currents in Shallow Water with Variable Eddy Viscosity, J. H. Thomas, *J. Phys. Oceanogr.* **5**, pp. 136-142, 1975.
Wind-Driven Circulation in Large Lakes with Spatially Variable Eddy Viscosity, A. J. Witten, *Ph.D. Thesis*, 1975.
Steady Wind-Driven Currents in a Large Lake with Depth-Dependent Eddy Viscosity, A. J. Witten and J. H. Thomas, *J. Phys. Oceanogr.* **6**, pp. 85-92, 1976.
Calculation of Steady Currents in Lake Ontario with Variable Eddy Viscosity, A. J. Witten, J. H. Thomas, *J. Great Lakes Res.*, in press.

137-09959-440-00

TRANSIENT WIND-DRIVEN CIRCULATIONS IN LARGE LAKES

(*c*) Alfred Clark, Jr., Professor.
(*d*) Theoretical investigation; basic research; Doctoral thesis.
(*e*) Identify the time-scales in the transient response of large lakes to time-varying winds.
(*f*) Completed.
(*g*) Analytical results are obtained for three-dimensional transient currents produced by a suddenly imposed, spatially variable wind stress, acting on a homogeneous lake of constant depth. The inertial period is always present in the response. The spin-up time is important only when the wind stress has a nonvanishing curl. The exact solution is compared with boundary layer theory, and it is shown that many features of interest are suppressed by boundary layer theory.
(*h*) **Time-Scales in Transient Wind-Driven Lake Circulations,** M. Zaki, *Ph.D. Thesis*, Univ. of Rochester, 1976.

137-09960-450-00

ROSSBY WAVES ON A MULTIPLE BETA-PLANE

(*c*) John H. Thomas, Assoc. Professor.
(*d*) Theoretical investigation; basic research.
(*e*) A multiple beta-plane is introduced to simulate the variation of the Coriolis parameter with latitude. The problem of reflection and refraction of plane Rossby waves at a discontinuity in beta has been solved. The multiple beta plane leads to Rossby waves trapped in a band about the equator, as is the case on the full sphere. Related laboratory experiments are planned.
(*h*) **Refraction of Rossby Waves on a Multiple Beta-Plane,** J. H. Thomas, R. A. Lux, in preparation.

137-09961-440-60

LONG-RANGE FORECASTING OF THE LAKE ONTARIO WATER LEVEL

(*b*) Sponsored in part by the New York State Assembly Scientific Staff with a grant from the National Science Foundation.
(*c*) John H. Thomas, Assoc. Professor.
(*d*) Theoretical investigation; applied research.
(*e*) A method for generating a forecast of the Lake Ontario water level one year or more in advance is developed, based on a transfer function relating the water level to rainfall on the upper Great Lakes. General procedures are outlined for integrating this new forecast procedure into the outflow control plan used in the St. Lawrence river.
(*f*) Completed.
(*h*) **A New Method for a Long-Range Forecast of the Lake Ontario Water Level,** F. Sciremammano, Jr., *Ph.D. Thesis, 1976.*

137-09962-000-20

PATHOLOGICAL BOUNDARY LAYERS

(*b*) Center for Naval Analyses, Office of Naval Research.
(*c*) Roger F. Gans, Asst. Professor.
(*d*) Experimental, theoretical; basic research.
(*e*) Objective is to understand observed eruption from singular circles in a rotating fluid by experimentally forcing this eruption. A theoretical picture is to be developed simultaneously.

137-09963-290-00

LABORATORY PLATE TECTONICS

(*c*) Roger F. Gans, Asst. Professor.
(*d*) Experimental, theoretical; basic research.
(*e*) A model of plate tectonic dynamics driven by heating from above, the object being to isolate phenomena caused by lateral temperature inhomogeneities in the lithosphere and the asthenosphere.
(*g*) Measurement of spreading rates as a function of ambient temperature and power levels of heating.
(*h*) **Laboratory Plate Tectonics: A New Experiment,** R. F. Gans, *Science* **191**, pp. 1276-1278 (1976).

137-09964-000-00

ROTATING GAS DYNAMICS

(*c*) Roger F. Gans, Asst. Professor.
(*d*) Theoretical; basic research.
(*e*) Calculation of various flow phenomena expected in rapidly rotating gas-filled cylinders and cylindrical annuli, including inertial and acoustic oscillations, resonance effects, steady-state flows, stability and nonlinear phenomena. A paradigm for fully compressible (non-Boussinesq) geophysical fluid dynamic phenomena. Applicable to high speed centrifuges.
(*g*) Identification and separation of inertial and acoustic modes; establishment of an inviscid stability criterion; identification of a viscosity-limited resonance.
(*h*) **On the Poincaré Problem for a Compressible Medium** R. F. Gans, *J. Fluid Mech.* **62**, pp. 657-675 (1974).
On the Gravitationally-Forced Motions of a Compressible Fluid Within a Horizontally-Rotating Container, R. F. Gans, *J. Fluid Mech.* **67**, pp. 611-624 (1975).
On the Stability of Shear Flow in a Rotating Gas, R. F. Gans, *J. Fluid Mech.* **68**, pp. 403-412 (1975).
Poiseuille-Like Flow in a Rotating Gas, R. F. Gans, *Phys. Fluids* **19**, pp. 1821-1823 (1976).

137-09965-000-54

FLOW IN PARTIALLY-FILLED CYLINDERS

(*b*) National Science Foundation.
(*c*) Roger F. Gans, Asst. Professor.
(*d*) Experimental, theoretical; basic research, thesis.

(*e*) A continuing effort to understand stability and nonlinear phenomena observable in a partially-filled cylinder with its rotation axis horizontal.
(*g*) A steady-state, nonlinear, viscous analysis of the flow has been completed. Careful measurements of the flow at the air-water interface have been made.
(*h*) **On Steady-State Flow in a Partially-Filled Rotating Cylinder,** R. F. Gans, *J. Fluid Mech.* (in press).

ROCKWELL INTERNATIONAL CORPORATION, Rocketdyne Division, 6633 Canoga Avenue, Canoga Park, Calif. 91304.

138-10181-550-50

ENGINE HYDRAULIC STABILITY

(*b*) National Aeronautics and Space Administration (Johnson Space Center).
(*c*) Dr. Robert C. Kesselring.
(*d*) Theoretical, applied research/design.
(*e*) Development of an analytical (computer) model and design criteria for the prevention of instability coupling between the injector hydraulics and the combustion process in liquid rocket combustors.
(*f*) Completed.
(*g*) An analytical liquid propellant rocket injector model was developed specifically, using the "lumped parameter" technique, to analyze combustion instability coupling between the injector hydraulics and the combustion process. This digital computer dynamic injector model will, for any imposed chamber or inlet pressure profile with a frequency ranging from 100 to 3000 Hz (minimum), accurately predict/calculate the instantaneous injector flowrates. The model was correlated with experimental data from three injectors–the Rocketdyne Lance XRL Booster injector, the Aerojet Space Shuttle OME Technology injector, and the Rocketdyne Space Shuttle OME Technology injector. Each of these injectors experimentally exhibited hydraulic coupling in the 100- to 3000-Hz range. In addition, experimentally proven hardware fixes which successfully eliminated the instability, exist for each of the three "correlation" injectors. The engine hydraulic stability computer model was run for each of the "correlation" injectors with both pre-fix and post-fix injector model input. Examination and analysis of the model output revealed that the computer model successfully predicted that the fixes applied to each correlation injector would increase combustor stability with respect to the instability model actually observed. The establishment of injector design criteria was attempted by conducing a sensitivity analysis with the model through a systematic study of various injector design variables using the model to constantly gauge the effects relative to injector gain (stability).

RUTGERS UNIVERSITY, The State University of New Jersey, College of Engineering, Department of Mechanical, Industrial and Aerospace Engineering, Piscataway, N.J. 08854. Dr. C. F. Chen, Department Chairman.

139-07616-090-00

SEPARATED FLOWS

(*c*) Professor R. H. Page and Assoc. Professor C. E. G. Przirembel.
(*d*) Experimental and theoretical basic research.
(*e*) Basic research in separated flows is being carried out to determine a much more fundamental understanding of the thermodynamic and dynamic mechanisms.
(*g*) Special experimental research facilities have been developed and theoretical models of various separated or separating flows have been formulated.
(*h*) **Time-Dependent Behavior of Separated Flow Regions,** T. A. DeRossett, C. E. G. Przirembel, *Proc. 20th Intl. Instrumentation Symp.*, Instr. Soc. of Amer., Albuquerque, N. Mex., May 1974.
Cinematographic Study of Separated Flow Regions, R. H. Page, C. E. G. Przirembel, *Paper No. 38, AGARD Conf. Proc. No. 168 on Flow Separation*, Gottingen, Germany, May 1975.
Convective Heat Losses from Single-Dwelling Residential Units, C. E. G. Przirembel, L. S. Fletcher, E. W. Harding, R. S. Nacht, *Proc. 12th Southeastern Sem. on Thermal Sciences*, Univ. of Virginia, June 1976.
Discussion on Generalized Flow Across an Abrupt Enlargement, C. E. G. Przirembel, T. A. DeRossett, *J. Engrg. for Power, ASME Trans.* **98,** Series A, 3, July 1976.
Heat Transfer in Separated and Reattached Flow: An Annotated Review, L. S. Fletcher, D. G. Briggs, R. H. Page, *Israel J. Technology* **12,** 3-4, pp. 236-261, 1974.
Subsonic Separation from Bluff Bodies, R. H. Page, *Bull. of APS, Series II*, **21,** 10, p. 1233, 1976.

139-07618-720-80

EMIL BUEHLER WIND TUNNEL

(*b*) Emil Buehler Foundation.
(*c*) Professor R. H. Page.
(*d*) Design; development.
(*e*) Design, operation, and development, of a supersonic variable Mach number wind tunnel and auxiliary apparatus for teaching and research programs. A variable Mach number wind tunnel (up to Mach 4.0) has been used extensively since it was first operated on April 21, 1964. It is used for teaching and research programs.
(*g*) Improvements in the tunnel's operation have been continuously made.
(*h*) **Aerothermodynamic Base Heating,** Y. Inoue, R. H. Page, *AIAA 12th Thermophysics Conf., Paper No. 77-755*, Albuquerque, N. Mex., 1977.

139-07619-600-00

FLUIDICS RESEARCH

(*c*) Professor R. H. Page.
(*d*) Theoretical and experimental investigations.
(*e*) Theoretical analyses of separating and reattaching flows are being carried out and verified with specially designed experiments.
(*g*) Basic fluid mechanics of separation and reattachment of fluidic devices has been formulated.

139-07621-030-26

THE TURBULENT WAKE OF AN AXISYMMETRIC BODY AT SUBSONIC SPEEDS

(*b*) Rutgers Research Council.
(*c*) Associate Professor C. E. G. Przirembel.
(*d*) Experimental, theoretical; basic research.
(*e*) The near-wake of an axisymmetric body, which is immersed in a uniform subsonic flow field, has been investigated experimentally and theoretically. The basic model was a circular cylinder aligned with the free stream direction. The geometry of the base was varied depending on the purpose of the particular investigation. Fundamental understanding of this near-wake flow field is necessary for the prediction of base drag, base heat transfer, and the configuration of the associated far wake. For example, this type of flow field characterizes fluid motion around such diverse objects as missiles, aircraft, buses and flowmeter elements.
(*f*) Completed.
(*g*) The support system for these models was designed to eliminate any support interference effects on the free stream and the approaching boundary layer. Detailed pressure and velocity measurements in all regions of the near-wake and in the approaching flow have been obtained for numerous base geometries. Results are discussed in the various publications listed below.

(*h*) **The Effect of Mass Removal From a Subsonic Axisymmetric Near-Wake,** C. E. G. Przirembel, R. A. Riddle, *Developments in Mechanics Conf.*, Oklahoma Univ., Mar. 1975.
Incompressible Turbulent Wakes of Axisymmetric Bodies, C. E. G. Przirembel, *Proc. 12th Southeastern Sem. Thermal Sciences*, Univ. of Virginia, June 1976.

139-08259-020-54

TURBULENCE AND TURBULENT DIFFUSION IN STRATIFIED FLOW

(*b*) National Science Foundation.
(*c*) Professor Richard L. Peskin.
(*d*) Theoretical and experimental research.
(*e*) Determine atmospheric turbulence parameters which control turbulent diffusion under varying stability conditions. Multi-tower hot-wire arrays were used to acquire data on atmospheric turbulence in the lower boundary layer. Horizontal space-time statistics have been acquired for three stability conditions. Coherence, phase and space-time correlation have been processed from the data and estimates made of the turbulent diffusion coefficients. Studies were also undertaken into the feasibility of developing a rotating hot-wire system for atmospheric applications.
(*h*) **Free-Shear Layer Instability Due to Probe Rotating Source Sink Flows,** C. Cerasoli, *J. Fluid Mechanics* **72,** 1975.
Baroclinic Instabilities of Deep Fluid, J. Hyun, R. L. Peskin, *J. Atmospheric Sciences* **33,** 1976.
Application of Integral Methods to Rotation Dominant Stratified Flows, J. Hyun, *Japanese J. Oceanography*, 1976.
Field Measurements of Space-Time Correlations in the Atmospheric Boundary Layer, R. M. C. So, R. L. Peskin, S. Guimard, *Proc. 2nd U.S. Conf. Wind Engrg.*, 1975.

139-08950-290-15

ANALYSIS OF RESONANCE TUBES

(*b*) Rutgers Research Council.
(*c*) Associate Professor C. E. G. Przirembel.
(*d*) Experimental, theoretical; basic research.
(*e*) The flow fields associated with two-dimensional and axisymmetric resonance tubes are being investigated. The test parameters, which are being varied in the experimental program, are the nozzle jet stagnation pressure, the separation distance between the nozzle and the resonance tube entrance, and the relative length of the resonance tube. Time-dependent and time-averaged pressures and temperatures are being obtained in the resonance tube. Color Schlieren, Schlieren and shadowgraph flow visualization techniques, in conjunction with high speed motion picture techniques, are used in observing and analyzing the jet and resonance tube flow fields.
(*g*) For a two-dimensional resonance tube with a blunt leading edge, it has been determined that the maximum resonant condition exists when the leading edge is located in the third compression cell of the underexpanded jet. Resonance also occurs for subsonic jet flow field in order to initiate a resonant condition. The time-dependent pressure measurements have been used to construct wave diagrams for the flow in the resonance tube.
(*h*) **The Aerothermodynamics of a Simple Resonance Tube,** C. E. G. Przirembel, L. S. Fletcher, *AIAA Paper No. 75-687, AIAA 10th Thermophysics Conf.*, Denver, Colo., May 1975.
Thermodynamic Characteristics of a Blunt, Two-Dimensional Resonance Tube, C. E. G. Przirembel, D. E. Wolf, L. S. Fletcher, *AIAA Paper No. 76-145, AIAA 14th Aerospace Sciences Mtg.*, Washington, D.C., Jan. 1976.
Aerothermodynamics of a Simple Resonance Tube, C. E. G. Przirembel, L. S. Fletcher, *AIAA J.* **15,** 1, Jan. 1977.
Aerothermodynamic Characteristics of a Resonance Tube Driven by a Subsonic Jet, C. E. G. Przirembel, D. E. Wolf, *AIAA Paper No. 77-236, AIAA 15th Aerospace Sciences Mtg.*, Los Angeles, Calif., Jan. 1977.

139-08951-050-00

HIGH SPEED WATER JET

(*c*) Professor R. H. Page.
(*d*) Theoretical and experimental investigations.
(*e*) Stability of high-velocity liquid jets are investigated. Experimental program utilizes a small diameter pulsed liquid jet with several nozzle designs at a maximum velocity of 1,000 meters per second.
(*g*) A model based on small perturbation theory with linearized equations of motion was chosen for analysis. Short time duration laser photographs of water and glycerine-water jets exhibited a ring-type instability having a small wave length. A non-interfering probe consisting of a miniature pressure cell utilizing strain gages was developed in order to measure pressures in the water jet.
(*h*) **Measurements in a Small High Pressure Jet,** A. M. Misuraca, R. H. Page, *Proc. 5th Canadian Congress of Applied Mechanics*, May 1975.
High Velocity Water Jet Stability, J. C. Dunn, R. H. Page, *Fluid Mechanics in the Petroleum Industry, ASME*, pp. 29-36, 1975.
An Instrument for Measurements in a Small High-Pressure Water Jet, A. M. Misuraca, R. H. Page, *Proc. Southeastern Sem. Thermal Sciences*, Univ. of Virginia, 1976.

139-10127-020-54

DOUBLE-DIFFUSION CONVECTION

(*b*) National Science Foundation.
(*c*) Professor C. F. Chen.
(*d*) Experimental and theoretical; basic research.
(*e*) Objective of research is twofold, to continue a basic study in double-diffusive convection, in particular to investigate theoretically the stability of double-diffusive convection along a sloping wall; and to apply the basic knowledge to practical problems. Specifically, the tasks to be accomplished are the experimental investigation of the effect of boundary inclination on double-diffusive convection; stability analysis of double-diffusive convection in the presence of a sloping boundary; experimental investigation of a laboratory solar pond; and thermal dispersion in stratified surroundings.
(*g*) The experimental investigation of the effect of boundary inclination on double-diffusive construction, and the experimental investigation of a laboratory solar pond are finished and the results are reported in publications listed below.
(*h*) **Double-Diffusive Convection in an Inclined Slot,** C. F. Chen, *J. Fluid Mech.* **72,** pp. 721-729, 1975.
Cellular Convection in a Density Stratified Fluid: Effect of Inclination of the Heated Wall, C. F. Chen, R. C. Paliwal, S. B. Wong, *Proc. 1976 Heat Transfer and Fluid Mechanics Inst.*, pp. 18-32, Stanford Univ. Press, 1976.
Sizes and Shapes of Salt Fingers Near the Marginal State, C. F. Chen, R. D. Sandford, *J. Fluid Mech.* **72,** pp. 601-607, 1976.
Laboratory Solar Pond, C. F. Chen, S. Thangam, *Proc. Solar Cooling and Heating Symp.*, Univ. of Miami, 13-15 Dec. 1976.

139-10128-130-54

DROPLET MOTION INDUCED BY SHOCK WAVES

(*b*) National Science Foundation.
(*c*) Professor S. Temkin.
(*d*) Experimental and theoretical; basic research.
(*e*) This study is concerned with the unsteady motion of small water droplets responding to the passage of weak shock waves. The study was undertaken with the purpose of determining some of the effects of unsteadiness on the motion of the droplets, particularly on instantaneous drag coefficients.
(*g*) For small, nondeforming water droplets, i.e. those with small Weber numbers, it has been found that the measured drag coefficients are larger than the "standard" coeffi-

cients at the same Reynolds number. The departures are smaller than those reported by other investigators in the past. Nevertheless, as the Reynolds number decreases, the departures increase. These departures are ascribed to the unsteadiness of the flow in the vicinity of the droplets. Other parts of this investigation include that of measurements of droplet deformation, and of analytical study of motion due to sound fields.

(*h*) **On the Response of a Sphere to an Acoustic Pulse,** S. Temkin, *J. Fluid Mechanics* **54,** pp. 339-349, 1972.
A Study of the Motion, Deformation and Breakup of Accelerating Water Droplets, J. M. Reichman, *Ph.D. Thesis,* Dept. of Mech., Industrial and Aerospace Engrg., Rutgers Univ., 1973.
A Study of the Deformation and Breakup of Accelerating Water Droplets, J. M. Reichman, S. Temkin, *Proc. Intl. Colloquium on Drops and Bubbles,* Pasadena, Calif., pp. 446-464, 1974.
On the Velocity of a Rigid Sphere in a Sound Wave, S. Temkin, *J. Sound and Vib.* **49,** pp. 75-92, 1976.
An Experimental Study of Droplet Response to Weak Shock Waves, S. S. Kim, *Ph.D. Thesis,* Dept. of Mech. Industrial and Aerospace Engrg., Rutgers Univ., 1977.

139-10129-010-26

BOUNDARY LAYER SEPARATION FROM A SLENDER BODY AT HIGH ANGLES OF ATTACK

(*b*) Air Force Office of Scientific Research (AFSC).
(*c*) Assoc. Professor C. E. G. Przirembel.
(*d*) Experimental and theoretical.
(*e*) The three-dimensional boundary layer separation process and the roll-up of the associated free-shear layer, which characterize the flow field in the vicinity of a slender body at moderate to high angles of attack, are being investigated. The improved understanding of these flow characteristics will assist in the rational modification of existing numerical calculations of aerodynamic forces and moments for slender bodies at high angles of attack.
(*h*) **Aerodynamics of Slender Bodies at Angles of Attack–A Critical Review,** C. E. G. Przirembel, High Speed Aero Performance Branch, Aeromechanics Division, Air Force Flight Dynamics Lab., *AFFDL-TM-76-92-FXG,* Aug. 1976.

139-10130-060-54

COUETTE INSTABILITY OF STRATIFIED FLUIDS

(*b*) National Science Foundation.
(*c*) Professor C. F. Chen.
(*d*) Experimental and theoretical; basic research.
(*e*) Investigate Couette instability of stably stratified fluid between two concentric rotating cylinders both experimentally and theoretically. Experiments will be carried out in a Couette apparatus which is capable of providing radius ratios of 0.5 and 0.9. For the small gap case, the analogy between the stratified Couette flow and rotating Benard connection will be examined. Furthermore, linear stability analysis of this flow will be carried out assuming asymmetric disturbances.
(*g*) The stability of such a system with respect to axisymmetric disturbances has been analyzed. Results compare favorably with experimental results obtained previously.
(*h*) **Stability Analysis of Rotational Couette Flow of Stratified Fluids,** E. M. Withjack, C. F. Chen, *J. Fluid Mech.* **68,** pp. 157-175, 1975.

139-10559-020-54

TURBULENCE STRUCTURE FOR APPLICATION TO WIND ENGINEERING

(*b*) National Science Foundation.
(*c*) Professor Richard L. Peskin.
(*d*) Theoretical and experimental research.
(*e*) To study turbulent shear flow as it occurs under real conditions and model turbulent diffusion and Reynolds stress for applications to problems in wind engineering. Emphasis is on measurements obtained from field experiments in the lower atmospheric boundary layer to provide parameters for predicted models for turbulent diffusion from point sources in real shear flows. Lagrangian correlations were used to construct diffusion coefficients which accurately reflect effects of shear gradients. Studies were also done on Reynolds stress models for the atmospheric boundary layer.
(*h*) **A Turbulence Philosophy Scale for Curved Shear Flows,** R. M. C. So, *J. Fluid Mechanics* **70,** 1975.
Some Fundamental Research Problems in Gas-Solid Flows, R. L. Peskin, *AIChE Symp. Ser. No. 147, Air Pollution* **71,** 1975.
Digital Computer Simulation of Turbulent Diffusion, R. L. Peskin, *Advances of Computer Methods for Partial Differential Equations, AICA,* 1975.
Entry Flow in Curved Channels, R. M. C. So, *J. Fluids Engrg.,* 1976.
An Approximate Method for Curved Shear Layers, R. M. C. So, *J. Fluids Engrg.,* 1976.
The Effects of Streamline Curvature on the Law of the Wall, *Proc. 12th Ann. Mtg. Soc. Engrg. Science,* 1975.
Momentum Integral for Curved Shear Layers, R. M. C. So, *J. Fluids Engrg.* **97,** 1975.

SANDIA LABORATORIES, Fluid and Thermal Sciences Department 1260, Albuquerque, N. Mex. 87115. Dr. K. J. Touryan, Department Manager.

141-08266-020-52

STATISTICAL TURBULENCE

(*b*) Energy Research and Development Administration.
(*c*) Dr. R. L. Fox.
(*d*) Theoretical.
(*e*) Develop tractable statistical methods for predicting turbulent flow.
(*g*) The turbulence field is represented as a system of interacting fluid elements. The movement of the fluid is determined by a set of relations which reproduce the Navier-Stokes equations when appropriate averages are applied. Prediction of the behavior of isotropic flow and free shear flow have been developed for incompressible fluids, and the method has been extended to compressible flows and mixing flows.
(*h*) **Solution of the Multipoint Distribution Function Equations for Non-Isotropic Free Turbulence,** R. L. Fox, *Research Rept. SAND 76-0187,* request from author.
Multipoint Distribution Function Hierarchy for Compressible Turbulent Flow, *Phys. Fluids* **18,** p. 1245 (1975).

141-08973-010-52

COMPUTATIONAL FLUID DYNAMICS FOR INTERNAL FLOWS

(*b*) Energy Research and Development Administration.
(*c*) Dr. Frederick G. Blottner.
(*d*) Development.
(*e*) Development of numerical codes that are to be used in the design and evaluation of coal-combustion-operated MHD generators and diffusers.
(*g*) A computer code has been developed for predicting the two-dimensional flow in channels where the slender channel approximation is utilized. The technique solves the flow across the complete channel and allows the wall boundary layers to be either laminar or turbulent. The code includes a quasi-two-dimensional option which provides an approximate technique for calculating three-dimensional duct flows. Flows with or without MHD forces can be calculated and the gas model assumes either a perfect gas or chemical equilibrium. Comparison of the numerical results with several experiments corroborate the validity of the code and governing equations being used.

(*h*) **Numerical Solution of Slender Channel Laminar Flows,** F. G. Blottner, *Computer Methods in Applied Mechanics and Engrg.* **10,** 3, 1977.
Entry Flow in Straight and Curved Channels with the Slender Channel Approximation, F. G. Blottner, *J. Fluids Engrg.*, to be published. (*ASME Paper No. 77-FE-2*).

141-10014-190-52

ISOTOPE ENRICHMENT

(*b*) Energy Research and Development Administration.
(*c*) Dr. R. L. Fox and Dr. R. R. Eaton.
(*d*) Theoretical, applied research.
(*e*) The failure of the Navier-Stokes equations for calculating certain classes of problems such as flows involving trace elements and/or disparate mass gas mixtures requires the development of alternate methods. A set of equations are derived from the Boltzmann equations using an ordering system based on relative collision frequency and effectiveness of collisions between the individual constituents. The second method developed is a Monte Carlo type particle tracing method referred to as the tracer-field method. Trace molecules are followed dynamically. They collide with the time-dependent field molecule distribution functions. Several computational solutions are given comparing both methods.
(*g*) Geometries for which the above method have been used to obtain solutions include colliding jets, curved nozzles, and two-dimensional channels.
(*h*) **Investigation of Nozzles, Jets, and Channels for the Separation of Heavy Isotopes,** R. L. Fox, R. R. Eaton, *10th Intl. Rarefied Gas Dynamics Symp. Proc.*, July 1976.
Isotope Enrichment by Aerodynamic Means: Some Theoretical Considerations, R. R. Eaton, R. L. Fox, K. J. Touryan, *AIAA J. of Energy*, June 1977.
Computational Methods for Flows Involving Trace Elements and Disparate Masses, R. R. Eaton, R. L. Fox, *Proc. 3d Computational Fluid Dynamics Conf.*, June 1977.
Flow Equations for Ternary Gases in Aerodynamic Separation of Uranium Isotopes, R. L. Fox, R. R. Eaton, *Research Rept. SAND 75-0176*, Jan. 1977, request from author.
Investigation of Nozzles, Jets, and Channels for Separation of Heavy Isotopes, R. L. Fox, R. R. Eaton, *Research Rept. SAND 76-0598*, Dec. 1976, request from author.
Calculation of Multicomponent Flows in the Aerodynamic Separation of Uranium Isotopes, R. R. Eaton, R. L. Fox, *Research Rept. 76-0004*, Mar. 1976, request from author.

SCRIPPS INSTITUTION OF OCEANOGRAPHY, University of California, San Diego, La Jolla, Calif. 92093. William A. Nierenberg, Director; Professor Douglas L. Inman, Head, Hydraulics Laboratory, and John Powell, Resident Engineer.

142-10394-420-44

STEADY STREAMING AROUND CIRCULAR BODIES UNDER LINEAR SURFACE WAVES

(*b*) NOAA, Sea Grant.
(*c*) Dr. Douglas L. Inman or Scott Kenkins (graduate student).
(*d*) Experimental and theoretical, basic research with design considerations approached.
(*e*) Measurements of the forces resulting from laboratory scale waves on submerged spheres and cylinders. Measurements of the drift currents produced around these bodies with unseparated flow. Theoretical descriptions for these steady currents are being developed through successive approximations to the wave boundary layer equations.
(*g*) The streaming gives rise to Kutta-Joukowski forces which reduce the resultant of the wave pressure. The streaming has been described approximately by boundary layer theory for a flow regime limited to unseparated motion. Long chain polymer surfaced bodies exhibit reduced streaming.
(*h*) **Forces on a Sphere Under Linear Progressive Waves,** Jenkins and Inman, *Proc. 15th Intl. Conf. on Coastal Engrg., ASCE* 3, 1976.

142-10395-420-44

EXPERIMENTAL STUDY ON THE HYDRODYNAMIC FORCES ON BLUFFED BODIES AT SHALLOW SUBMERGENCE IN UNIDIRECTIONAL CURRENTS

(*b*) NOAA, Sea Grant.
(*c*) Dr. Douglas L. Inman or Scott Jenkins (graduate student).
(*d*) Experimental and theoretical, basic research with design considerations approached.
(*e*) Measurements of wave form drag on bluffed bodies moving through still water at shallow submergence. Studies in reducing wave and form drag by means of pressure recovery using Stratford's criterion for separation of a turbulent boundary layer.
(*g*) The form drag has been found to exceed the wave drag by an order of magnitude. The wave drag has been found to be comparable in size to that predicted in recent nonlinear potential flow solutions.

142-10396-130-44

DUCT FLOW FLUIDIZATION STUDY

(*b*) NOAA, Sea Grant; Department of the Navy, Naval Facilities Engineering Command; U.S. Army Corps of Engineers, Waterways Experiment Station.
(*c*) Dr. Douglas L. Inman or James A. Bailard (graduate student).
(*d*) Experimental and theoretical applied research.
(*e*) Development of an analytic model predicting pressures and velocities in both the pipe and fluidized duct.
(*g*) Laboratory experiments verified theory. Field tests now in progress.
(*h*) **An Analytic Model of Duct-Flow Fluidization,** J. A. Bailard, D. L. Inman, *Symp. on Modeling Techniques, ASCE*, pp. 1402-21, 1975.

142-10397-430-22

TETHERED FLOAT BREAKWATER DEVELOPMENT PROJECT

(*b*) U.S. Naval Facilities Engineering Command; U.S. Army Corps of Engineers; California Department of Navigation and Ocean Development; Maritime Administration.
(*c*) Dr. Richard J. Seymour, Program Director.
(*d*) Experimental and theoretical investigations followed by field verification; Ph.D. thesis resulted.
(*e*) Hydrodynamic investigations of dynamic breakwater consisting of a large number of buoyant tethered floats which oscillate vigorously in a wave field and attenuate wave energy by drag dissipation.
(*g*) Scaling laws verified, predictive model developed for performance in random seas. Functional breakwater for limited fetch waves demonstrated.
(*h*) **TFB: A Transportable Open Ocean Breakwater,** M. E. Essoglou, R. J. Seymour, J. B. Berkley, *Proc. 11th Ann. Conf. Marine Tech. Soc.*, San Diego, Sept. 1975.
Resistance of Spheres in Oscillatory Flows, R. J. Seymour, *Ph.D. Dissertation*, 1974.
Wave Induced loads on Multielement Structures, R. J. Seymour, *Proc. Symp. Modeling Techniques for Waterways, Harbors and Coastal Engrg.*, San Francisco, Sept. 1975.
Tethered Float Breakwater: A Temporary Wave Protection System for Open Ocean Construction, R. J. Seymour, *OTC 2545, Proc. 8th Ann. Offshore Tech. Conf.*, Houston, Tex., May 1976.
Project status report containing bibliography of numerous project reports available from Project Director.

142-10398-420-54

WAVES ON BEACHES

(*b*) National Science Foundation; Office of Naval Research, Geography Programs.
(*c*) Robert T. Guza, Asst. Professor of Oceanography.

(*d*) Combined experimental-theoretical-field, basic research.
(*e*) Investigations into the dynamics of breaking and near-breaking gravity waves in shallow water.
(*g*) Nonlinear interactions, both resonant and nonresonant, play an important role in the overall wave energy distribution in very shallow water. There may be considerable resonant energy transfer from incident wave periods (10 sec) to rather longer surges (60 sec).
(*h*) **Resonant Interactions for Waves Breaking on a Beach,** R. T. Guza, A. J. Bowen, *Proc. 15th Intl. Conf. on Coastal Engrg., ASCE,* 1977.
Finite Amplitude Edge Waves, R. T. Guza, A. J. Bowen, *J. Mar. Res.* **34,** 1, pp. 269-93, 1976.

142-10399-420-20

EXPERIMENTAL STUDY OF SHOALING WAVES

(*b*) Office of Naval Research, Geography Programs, Code 462.
(*c*) Dr. Douglas L. Inman, Dr. Robert T. Guza, Mr. Reinhard E. Flick (graduate student).
(*d*) Experimental, basic research, Ph.D. thesis.
(*e*) Measurement of wave shoaling induced nonlinear energy transfer in single frequency and biharmonic surface gravity waves on gentle slopes. Elevation measurements using high resolution resistance wire gauges. Velocity measurements using hot film anemometers to describe turbulent fluctuations under spilling and plunging breakers. The effects of the paddle generation process, long channel dissipation, reflection and standing waves were measured.
(*f*) Completed. Thesis and papers in preparation.
(*g*) Comparison of harmonic amplitudes measured with a nonlinear Stokes theory and cnoidal theory. Description of turbulent velocity fluctuations under spilling and plunging breakers. Analytic breaking criterion for spilling type breakers based on the acceleration at the crest.
(*h*) Thesis and papers in preparation. Progress reports 1975-1976, 1977 from ONR Code 462, Geography Programs, c/o Dr. James Bailey.

142-10400-420-20

LABORATORY STUDIES OF BREAKING INTERNAL WAVES

(*b*) Office of Naval Research, Geography Programs.
(*c*) Dr. Clinton D. Winant, Alan Bratkovich (graduate student).
(*d*) Experimental, basic research.
(*e*) Observation of velocity and density microstructure at the leading edge of nonlinear internal waves (internal bores). Measurements are made in a Lagrangian frame fixed to the wave front in order to identify and describe related mixing processes.

142-10401-420-54

INTERACTION OF SOLITARY WAVES WITH BOUNDARIES

(*b*) National Science Foundation.
(*c*) Experimental basic research.
(*d*) Dr. Kenneth Melville, Asst. Research Geophysicist.
(*e*) Measurements of surface displacements of propagating waves in converging and diverging channels. Measurements of regular and Mach reflection of solitary waves against an inclined wall. To test recent theoretical predictions.

142-10402-410-60

ANISOTROPIC SAND TRANSPORT IN TIDAL INLETS

(*b*) California Department of Navigation and Ocean Development; Foundation for Ocean Research; and Institute for Marine Research.
(*c*) Steven L. Costa, Foundation for Ocean Research, 11696-D, Sorrento Valley Road, San Diego, Calif. 92126.
(*d*) Experimental, applied research, part of Ph.D. thesis.
(*e*) Experimental investigation of sediment transport dynamics in tidal inlets and the possible modification of inlet systems to enhance transport characteristics.
(*f*) Work continuing on theoretical aspects.
(*g*) Tidal inlets operate in a highly nonlinear sediment transport regime (both in model and field scales). Small changes to inlet channel flow result in inordinately large changes in sediment transport on the channel bed.
(*h*) **Anisotropic Sand Transport in Tidal Inlets,** S. L. Costa, J. D. Isaacs, *Proc. Symp. Modeling Techniques, ASCE,* 1975.
The Modification of Tidal Inlet Transport Dynamics Using Secondary Augmentation Flows, S. L. Costa, J. D. Isaacs, in preparation to be published in *Proc. Symposium on Coastal Sediments, ASCE,* Charleston, S.C., Nov. 1977.

UNIVERSITY OF SOUTHERN CALIFORNIA, Department of Aerospace Engineering, University Park, Los Angeles, Calif. 90007. Dr. John Laufer, Department Chairman.

143-09177-020-54

LABORATORY STUDIES OF A TURBULENT, STRATIFIED SHEAR LAYER

(*b*) National Science Foundation.
(*c*) Frederick K. Browand, Assoc. Professor.
(*d*) Experimental, basic research.
(*e*) The mixing layer is formed by merging two streams of different velocity and density. The purpose is to study the effect upon the turbulence of a statically stable density difference, with application to mixing in the ocean and atmosphere.

143-09178-010-26

GENERATION OF TURBULENCE IN THE TRANSITION OF A LAMINAR BOUNDARY LAYER

(*b*) Air Force Office of Scientific Research.
(*c*) Drs. Richard E. Kaplan and Edward R. Van Driest.
(*d*) Experimental and theoretical, applied research.
(*e*) Predictions and measurements of the location and nature of boundary layer transition.
(*g*) See publications below.
(*h*) **The Intermittently Turbulent Region of the Boundary Layer,** R. E. Kaplan, J. Laufer, *Proc. 12th Intl. Cong. Appl. Mech.,* Stanford Univ., Aug. 26-31, 1968; Springer, 1969.
Spatial Structure in the Viscous Sublayer, A. K. Gupta, J. Laufer, R. E. Kaplan, *J. Fluid Mech.* **50,** p. 493, Dec. 14, 1971.
Statistical Characteristics of Reynolds Stress in a Turbulent Boundary Layer, A. K. Gupta, R. E. Kaplan, *Physics of Fluids* **15,** 6, June 1972.
Intermittent Structures in Turbulent Boundary Layers, R. E. Kaplan, J. Laufer, Symp. volume for AGARD Specialist Mtg. on *Turbulent Shear Flows, AGARD-CP-93,* Technical Editing and Reproduction Ltd., London, 1972.
On the Wall Structure of the Turbulent Boundary Layer, R. F. Blackwelder, R. E. Kaplan, *J. Fluid Mechanics* **76,** 1, pp. 89-112, 1976.
The Coupling Between Freestream Disturbances, the Forced Oscillations, and the Natural Oscillations in a Spatial Analysis of a Boundary Layer, H. L. Rogler, presented *AGARD-NATO Fluid Dynamics Panel Symp.: Laminar-Turbulent Transition,* Copenhagen, Denmark, May 1977.

143-09179-010-54

RESEARCH ON BOUNDARY LAYERS

(*b*) National Science Foundation.
(*c*) Drs. John Laufer and Richard E. Kaplan.
(*d*) Experimental, basic research; Master's and Doctoral theses.
(*e*) Experimentally determine the large scale and wall structure of the turbulent boundary layer.
(*g*) Both the outer and inner regions of the turbulent boundary layer have been studied by multiple hot-wire and hot-film anemometer probes and by a mild heating of the wall. The measurements were analyzed on a digital computer by

the techniques best described as conditional sampling, and Hodograph plane joint probability densities and Lindeberg statistics. Much novel information about the nature of these structures has been found including their spatial geometry and evolution; the entrainment mechanisms; the statistics of the wall streaks; deep penetration of outer, poorly mixed fluid, and wall bursts. Additionally, experiments in artificial driving of disturbances have been performed with little success.

(*h*) See Project 143-09178-010-26 above.

143-09180-450-54

INTERNATIONAL SOUTHERN OCEAN STUDIES: LABORATORY MODELING STUDIES OF THE ANTARCTIC CIRCUMPOLAR CURRENT

(*b*) National Science Foundation.
(*c*) Professor Tony Maxworthy.
(*d*) Experimental, basic research, for Doctoral theses.
(*e*) Basic experimental study of rotating flows with and without stratification that are important in the study of ocean circulations. For the A.C.C. the constricting effect of the Drake Passage and other topographical features has been emphasized.
(*f*) Completed.
(*g*) The Drake Passage geometry has been found to greatly affect the circumpolar flow and accounts for the majority of the energy dissipation in the whole system.
(*h*) *Proc. 10th Ann. Mtg., Soc. Engrg. Sci.*, Raleigh, N.C., 1972.
Topographic Effects in Rapidly Rotating Fluids, *Z.A.M.P.*, Oct. 1977.

143-09181-010-14

RESEARCH ON WALL TURBULENCE

(*b*) U.S. Army Research Office–Durham.
(*c*) Ron Blackwelder, Assoc. Professor.
(*d*) Experimental, basic research; Master's and Doctoral theses.
(*e*) Experimentally determine the large scale and wall structure of the turbulent boundary layer.
(*h*) **Pressure Perturbation of a Turbulent Boundary Layer,** R. F. Blackwelder, H. H. W. Woo, *Phys. Fluids* **17,** 3, Mar. 1974.
On the Wall Structure of the Turbulent Boundary Layer, R. F.Blackwelder, R. E. Kaplan, *J. Fluid Mechanics* **76,** 1, pp. 89-112, 1976.

143-09182-000-54

THE DYNAMICS OF CONCENTRATED VORTICES

(*b*) National Science Foundation.
(*c*) Professor Tony Maxworthy.
(*d*) Experimental, basic research, for Doctoral theses.
(*e*) Experimental investigation of vortex rings, thermals and aircraft wakes in stratified and unstratified environments, using laser Doppler and photographic techniques.
(*f*) Completed.
(*g*) See publications below.
(*h*) **Turbulent Vortex Rings,** T. Maxworthy, *J. Fluid Mech.* **64,** pp. 227-239, 1974.
The Motion of Aircraft Trailing Vortices, T. Maxworthy, *J. Appl. Mech.* (to be published).
On the Motion of Turbulent Thermals, M. P. Escudier, T. Maxworthy, *J. Fluid Mech.* **61,** pp. 541-552, 1973.
On the Dynamics of Turbulent Thermals, Mohamed Gad-El-Hak, Abstract, *Bull. Amer. Phys. Soc.* **19,** 10, Paper CB6, Nov. 1974.
Some Experimental Studies of Vortex Rings, *J. Fluid Mech.*, in press.

143-09183-020-20

LARGE SCALE STRUCTURE AND ENTRAINMENT IN THE TURBULENT MIXING LAYER

(*b*) Office of Naval Research, Project SQUID.
(*c*) Frederick K. Browand, Assoc. Professor.
(*d*) Experimental, basic research.
(*e*) Additional sampling techniques are applied to the two-dimensional mixing layer to isolate and study the large-scale structure. Work should provide understanding of the basic nature of turbulent mixing and entrainment.

143-09902-420-50

DYNAMICS OF THE JOVIAN ATMOSPHERE

(*b*) National Aeronautics and Space Administration.
(*c*) Drs. Tony Maxworthy and Larry G. Redekopp.
(*d*) Experimental-theoretical, basic research, for Doctoral theses.
(*e*) A basic study of solitary wave motions in rotating-stratified and stratified media. These entities are used to model various atmospheric features in both the Jovian and terrestrial atmospheres.
(*g*) See h.
(*h*) **A Solitary Wave Theory of the Great Red Spot and Other Observed Features in the Jovian Atmosphere,** T. Maxworthy, L. G. Redekopp, *Icarus* **29,** pp. 261-171, 1976.
On the Production and Interaction of Planetary Solitary Waves: Application to the Jovian Atmosphere, T. Maxworthy, L. G. Redekopp, P. D. Weidman. Submitted to *Icarus*.

143-09903-450-20

THE DYNAMICS OF ROTATING AND NON-ROTATING INTRUSIONS

(*b*) Office of Naval Research.
(*c*) Drs. Tony Maxworthy and Frederick K. Browand.
(*d*) Experimental, basic research, for Doctorai theses.
(*e*) A basic experimental study of the formation of oceanic microstructure from the interleaving of fluid layers with different origins. A variety of facilities are used in which both the steady and unsteady motion of intrusive features can be studied in both rotating and nonrotating-stratified surroundings.
(*g*) See h.
(*h*) **On the Generation of Internal Solitary Waves from the Gravitational Collapse of Mixed Regions,** T. Maxworthy. Submitted to *J. Fluid Mechanics*.

143-09904-160-54

EXPERIMENTAL INVESTIGATION OF SUPERSONIC JET NOISE

(*b*) National Science Foundation.
(*c*) Professor Richard E. Kaplan.
(*d*) Experimental, basic research, Ph.D. dissertation.
(*e*) Investigate sources of "extra noise" for supersonic ideally expanded jets. Augment data acquisition facilities.

SOUTHAMPTON COLLEGE OF LONG ISLAND UNIVERSITY, Department of Geology, Southampton, N.Y. 11968.

144-09873-820-65

SALT WATER INTRUSION IN SE LONG ISLAND (Collaborative Project with Department of Geology and Geophysics, University of Wisconsin-Madison)

(*b*) Town of Southampton, Suffolk County, N.Y.
(*c*) Professor C. Alan Berkebile, Southampton College or Mary P. Anderson, Asst. Professor, University of Wisconsin-Madison.
(*d*) Field and theoretical, applied and development.
(*e*) Establish a network of groundwater observation wells in the Town of Southampton in order to determine the extent of salt water intrusion and to monitor sea water encroachment on a routine basis.
(*g*) A survey of 124 wells conducted during 1974-75 showed that water from 26 wells had chloride concentrations of 50 mg/l or greater and in 17 wells the chloride concentration exceeded 200 mg/l. These high concentrations are very

likely due to salt water intrusion. Nineteen of the contaminated wells are located in two densely populated areas in which private wells are used for water supply.

(*h*) **Evidence of Salt Water Intrusion in Southeastern Long Island,** M. P. Anderson, C. A. Berkebile, *Groundwater* **14,** 5, pp. 315-319, 1976.
Unsteady Groundwater Flow Beneath Strip Oceanic Islands, M. P. Anderson, *Water Resources Research* **12,** 4, pp. 640-644, 1976.
Town of Southampton, Groundwater Resources Monitoring Program, 1974-75, *Report to the Town of Southampton,* 110 pages, July 1975. Loan copies available from Southampton College.

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SOUTHERN METHODIST UNIVERSITY, School of Engineering and Applied Science, Civil and Mechanical Engineering Department, Dallas, Tex. 75275. Dr. Michael A. Collins, Assoc. Professor.

145-09930-210-33

SOLUTION OF LARGE SCALE PIPE NETWORKS BY IMPROVED MATHEMATICAL APPROACHES

(*b*) Office of Water Research and Technology, United States Department of the Interior.
(*c*) Dr. Michael A. Collins, Assoc. Professor.
(*d*) Experimental and theoretical; applied research.
(*e*) New theoretical models are being established for the classical pipe network analyses problems. It is proven there exist nonlinear optimization models whose solution yield the heads and discharge for a pipe network. Thus, as opposed to the traditional iteration methods, i.e., Hardy Cross, Newton Raphson, and linearization, nonlinear optimization techniques can be used to solve the classical pipe network analysis problem. Numerical experiments are being conducted to compare the relative efficiency of traditional methods to optimization solution methods.
(*g*) The existence of two complementary optimization models for nonlinear networks has been established. Numerical experiments on large scale networks have demonstrated the feasibility of an optimization approach to solving pipe network analyses problems.

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SOUTHWEST RESEARCH INSTITUTE, 8500 Culebra Road, P. O. Drawer 28510, San Antonio, Tex. 78284. H. Norman Abramson, Vice President, Engineering Sciences.

146-09299-340-70

STUDIES OF EARTHQUAKE-INDUCED FLUID MOTIONS IN TOROIDAL RESERVOIRS

(*b*) General Electric Nuclear Energy Division.
(*c*) Dr. D. D. Kana, Manager, Structural Dynamics and Acoustics.
(*d*) Experimental and theoretical; applied research.
(*e*) Experimental and analytical studies of earthquake-induced wave motions in the shallow, toroidal "suppression pool" reservoir of typical nuclear reactors.
(*g*) Both vertical and horizontal earthquake motions are simulated, using a two degree-of-freedom shake table. Various methods of damping the wave motions are also under investigation.

146-09300-110-70

STUDIES OF LIQUEFIED NATURAL GAS (LNG) MOTIONS IN PARTIALLY FULL TANKS

(*b*) Methane Tanker Service.
(*c*) Dr. Robert L. Bass, Manager, Hydro-Mechanical Systems.
(*d*) Experimental; applied research.
(*e*) Experimental determination of wave-impact pressures on tank walls.
(*g*) Scale-model studies using liquids with various physical properties, realistic tank geometries, and tank motions were conducted to determine correlating equations for wall pressures in full-scale tanks.

146-09301-620-70

SQUEEZE FILM DAMPERS FOR HIGH-SPEED ROTATING MACHINERY

(*b*) Union Carbide Nuclear Company.
(*c*) Dr. F. T. Dodge, Staff Engineer.
(*d*) Analytical; applied research and development.
(*e*) Analytical investigation of hydrodynamic squeeze film dampers for flexible, high-speed rotors.

146-09302-190-50

UNCONFINED VAPOR EXPLOSIONS

(*b*) National Aeronautics and Space Administration, Lewis Research Center.
(*c*) Dr. W. E. Baker, Institute Scientist, and Dr. R. A. Strehlow, University of Illinois.
(*d*) Applied research; theoretical and experimental.
(*e*) Assess damage potential of unconfined vapor explosions and other non-ideal explosions; determine energy released by back-calculations from measured pressure-time histories.
(*g*) A survey of damage mechanics and scaling relationships for non-ideal explosions has been completed. An analysis, using the method-of-characteristics, has been developed to determine the entire flow field and the energy flows resulting from a non-ideal explosion, using experimental pressure-time histories at one location. Calculations of the energy release and flow fields of bursting glass spheres under high pressure are underway to evaluate equivalent TNT yields of non-ideal explosions.
(*h*) **The Characterization and Evaluation of Accidental Explosions,** R. A. Strehlow, W. E. Baker (to be submitted).

146-09303-000-50

FLUID MECHANICS, THERMODYNAMICS, AND HEAT TRANSFER EXPERIMENTS IN SPACE

(*b*) National Aeronautics and Space Administration, Lewis Research Center,
(*c*) Dr. F. T. Dodge, Staff Engineer.
(*d*) Basic research.
(*e*) Determine meritorious experiments in fluid mechanics, thermodynamics, and heat transfer that must be conducted in space but have results applicable to earth-bound phenomena.
(*f*) Completed.
(*g*) An overstudy committee of nine members from university and research institute engineers and scientists was formed. Many experiments were identified and evaluated. The impact of a space laboratory environment on the conduct of the experiments was assessed.
(*h*) **Fluid Mechanics, Heat Transfer, and Thermodynamics Experiments for a Space Laboratory,** F. T. Dodge, H. N. Abramson, S. W. Angrist, I. Catton, S. W. Churchill, R. J. Mannheimer, S. Ostrach, S. H. Schwarts, J. V. Sengers, *NASA CR-134742,* (submitted to Science).

146-09304-050-15

CHARACTERISTICS OF HIGH-SPEED COMBUSTING JETS

(*b*) U.S. Army Ballistic Research Laboratory.
(*c*) Dr. F. T. Dodge, Staff Engineer.
(*d*) Theoretical; applied research.
(*e*) Studies of combusting jets issuing from tanks of compressed LPG.
(*g*) Using literature results and original analyses, predictions of the flow characteristics of highly-underexpanded two-phase jets of reacting LPG are being made. The heat transfer to insulated steel plates, placed at various distances from the jet orifice, are computed, with the eventual aim of reducing the "torching" hazard in LPG tank car derailments.
(*h*) SwRI Contractor Reports.

146-09305-740-00

FINITE-ELEMENT METHODS FOR FLUID MECHANICS

(*b*) SwRI Internal Research Panel.
(*c*) Dr. F. T. Dodge, Staff Engineer and Mr. R. E. Ricker, Engineer.
(*d*) Theoretical; basic research.
(*e*) Use of finite-element methods to analyze various potential flows with a free surface and environmental flow problems and to extend the usefulness of the method.

146-09306-640-00

FLUID-SHOCK PHYSICS

(*b*) SwRI Internal Research Panel.
(*c*) Dr. F. T. Dodge, Staff Engineer.
(*d*) Theoretical; applied research.
(*e*) Explore various techniques of predicting shock or blast-wave interactions with structures or other flow fields.

146-09310-550-22

WATERWHEEL TEST FACILITY FOR SURFACE EFFECT SHIPS SEAL FINGER PERFORMANCE STUDIES

(*b*) Surface Effect Ships Project Office, Department of the Navy.
(*c*) Dr. R. L. Bass, Manager, Hydro-Mechanical Systems.
(*d*) Experimental applied research and test facility design.
(*e*) Design of a large-scale waterwheel to provide high-speed hydrodynamic free surface testing.
(*g*) Hydrodynamic problems of propulsion, stability, and sea-keeping on surface effect ships employing flexible bow and stern seals are secondary compared to seal service life shortcomings. Seal service life is adversely affected by wear and fatigue incurred in normal SES operation, and the relatively short service life of the seals is a major limiting factor in SES design and operation. To gain additional information for improving seal life, large scale test facilities are needed to monitor seal life in realistic environmental and operating conditions. A paper study was performed to determine the feasibility of utilizing a large-scale waterwheel as a test facility for measuring SES seal failure modes and fatigue service life. The operational and design requirements of such a facility have been established and the design of a waterwheel test rig for determining lower seal wear is currently underway.
(*h*) SwRI Contractor Reports.

146-10354-130-70

SCALE MODELING STUDIES OF BWR BLOWDOWN FLUID PHYSICS

(*b*) General Electric Nuclear Energy Systems Division.
(*c*) Dr. F. T. Dodge, Staff Engineer.
(*d*) Experimental and analytical; applied research.
(*e*) Formulate scale-modeling laws and interpret results of tests of massive air/steam injection into water pools.

·146-10355-050-50

LIQUID JET IMPINGEMENT ON CLOSELY-WOVEN SCREENS

(*b*) NASA-Lewis Research Center.
(*c*) Dr. F. T. Dodge, Staff Engineer.
(*d*) Analytical; applied research.
(*e*) Develop math model of through-put of incompressible jet impinging on a screen.
(*g*) Good correlation with test data has been achieved; final report is in preparation.

146-10356-650-70

SLOSH DYNAMICS OF OIL PRODUCTION EQUIPMENT

(*b*) AMOCO.
(*c*) Dr. F. T. Dodge, Staff Engineer.
(*d*) Analytical; applied research.
(*e*) Determine susceptibility of conventional 3-phase separators, glycol de-gassers, etc., to performance degradation by slosh effects encountered on flexible off-shore platforms.

146-10357-540-50

FLOW INDUCED VIBRATIONS OF BELLOWS

(*b*) NASA-Marshall Space Flight Center.
(*c*) Mr. J. E. Johnson, Engineer.
(*d*) Analytical; applied research.
(*e*) Extend previous research to cover bellow sizes used in the Space Shuttle.

146-10358-520-45

BULK CARRIER SAFETY ENHANCEMENT

(*b*) Maritime Administration.
(*c*) Dr. R. L. Bass, Manager, Hydro-Mechanical Systems.
(*d*) Analytical and experimental; applied research.
(*e*) Analyses and scale-model tests of ventilating and gas-freeing large supertanker tanks.
(*g*) Phase 1 Final Report issued June 1976.

STANFORD UNIVERSITY, Department of Applied Earth Sciences, School of Earth Sciences, Stanford, Calif. 94305. Professor Irwin Remson.

147-08979-810-54

HYDROLOGIC MODELS FOR LAND–USE MANAGEMENT

(*b*) National Science Foundation.
(*c*) Cooperative project with Department of Geology.
(*d*) Theoretical research with field applications; applied research; M.S. and Ph.D. theses.
(*e*) Development of deterministic and optimization computer models of subsurface hydrology for use in studying and managing watershed hydrology.
(*g*) List of papers available on request.

147-10473-820-54

HYDRAULIC AND HYDROLOGIC BEHAVIOR OF INFLUENT STREAMS AND RECHARGE OF UNDERLYING AQUIFERS (See also Stanford Civil Engineering Department, 148-1049)

(*b*) National Science Foundation.
(*c*) Professors Joseph B. Franzini and Irwin Remson (cooperative project with Department of Civil Engineering).
(*d*) Theoretical research with laboratory and field applications; applied research; M.S. and Ph.D. theses.
(*e*) Use of theoretical models and laboratory and field data to study the behavior of influent streams.
(*g*) Only preliminary results.

STANFORD UNIVERSITY, Department of Civil Engineering, Stanford, Calif. 94305. Professor R. L. Street, Department Chairman.

148-10406-420-14

THE GROWTH OF OCEAN WAVES UNDER THE ACTION OF THE WIND

(*b*) U.S. Army Research Office, Durham, N.C.
(*c*) Professor E. Y. Hsu.
(*d*) Experimental; basic research for Doctoral theses.
(*e*) To study the effect of turbulence in the energy transfer process from wind to water waves. The proposed experiments include studies of the detailed flow structure by measuring the instantaneous wind profiles over the air-water interface.
(*h*) Complete list of reports and papers available on request to correspondent.

148-10407-010-54

EXPERIMENTAL STUDIES IN THE STRUCTURE OF TURBULENT BOUNDARY LAYER GROWING ON A DEFORMABLE AIR-WATER INTERFACE

(*b*) Engineering Division, National Science Foundation.
(*c*) Professor E. Y. Hsu.
(*d*) Experimental; basic research for Doctoral theses.
(*e*) The proposed research is devoted to the more precise establishment of the similarities and differences in the structure of turbulence in boundary layers over rigid and deformable (wave-perturbed) surfaces.
(*h*) Complete list of reports and papers available on request to correspondent.

148-10408-420-20

WIND-GENERATED WATER WAVES

(*b*) Professors E. Y. Hsu and R. L. Street.
(*d*) Experimental; basic research for Doctoral theses.
(*e*) The program is devoted to measurement of wave-induced turbulent Reynolds stresses and their contribution to the momentum transfer from the wind to the surface wave field at the air-water interface.
(*h*) Complete list of reports and papers available on request to correspondents.

148-10409-820-54

HYDRAULIC AND HYDROLOGIC BEHAVIOR OF INFLUENT STREAMS AND RECHARGE OF UNDERLYING AQUIFERS

(*b*) Engineering Division, National Science Foundation.
(*c*) Professor Joseph B. Franzini, Dept. of Civil Engineering, and Professor Irwin Remson, Dept. of Applied Earth Science.
(*d*) Theoretical and experimental; basic research for Doctoral theses.
(*e*) Initially the kinematic wave equation for flow in a very wide channel on a constant slope will be linked numerically to the one-dimensional Richard's equation for unsteady, unsaturated flow in soils. In later work the investigation will be extended to include variation in channel slope, width and depth, variation of the characteristics of the underlying strata, and the effect of lateral spreading of the seepage water.

148-10410-860-36

RECLAIMED WATER IN PALO ALTO

(*b*) Environmental Protection Agency.
(*c*) Professors Perry L. McCarty (Principal Investigator) and Paul V. Roberts (Project Manager).
(*d*) Basic and applied research; development of theoretical models followed by calibration and verification in the laboratory and in the field; Doctoral theses.
(*e*) The effects of injecting treated wastewater into an aquifer are being investigated with special emphasis on the transformations and fates of trace contaminants and changes in the hydrogeologic and mineralogic characteristics of the aquifer. A coupled model describing flow and water quality characteristics is being developed.
(*h*) **Preproject Water quality Evaluation for the Palo Alto Water Reclamation Facility,** Dept. of Civil Engrg., *Tech. Rept. No. 206*, Apr. 1976.

148-10411-530-21

FINITE ELEMENT SIMULATION OF THREE-DIMENSIONAL FLOW ABOUT FULLY CAVITATING HYDROFOILS

(*b*) Naval Ship Research and Development Center.
(*c*) Professor R. L. Street.
(*d*) Theoretical, numerical computation, basic research for Doctoral theses.
(*e*) Develop a numerical finite element computational method for the solution of three-dimensional, irrotational, steady and fully-cavitating flow past arbitrary hydrofoils or other bodies. A fully nonlinear computation method, as is being developed, will have application in the design of hydrofoils and propellors.
(*g*) **Numerical Methods Applied to Fully Cavitating Flows, with Emphasis on the Finite Element Method,** R. L. Street, P. Y. Ko, *Symp. on Hydrodynamics of Ship and Offshore Propulsion Systems*, Det Norske Veritas, Oslo, Norway, 1977.

148-10412-440-33

SIMULATION OF THERMALLY-INFLUENCED HYDRODYNAMIC FLOWS

(*b*) Office of Water-Resources Research, Department of the Interior.
(*c*) Professor R. L. Street.
(*d*) Theoretical, numerical computation, basic research for Doctoral theses.
(*e*) Under the project we developed a time-dependent, three-dimensional numerical model which simulates the hydrodynamics and thermal regime of lakes and reservoirs; and a two-dimensional (horizontal-vertical) hydrostatic numerical model for simulation of hydrodynamics and thermal regimes (e.g., thermocline development) in long and narrow reservoirs and lakes.
(*f*) Completed.
(*g*) Complete list of reports and papers available on request to correspondent.

148-10413-140-54

HEAT TRANSFER AT A MOBILE BOUNDARY

(*b*) Engineering Division (Heat Transfer Program), National Science Foundation.
(*c*) Professor R. L. Street.
(*d*) Experimental and theoretical, basic research for Doctoral theses.
(*e*) The work is focused on the transport processes occurring at a gas-liquid interface under the action of a turbulent gas flow. We seek experimental determination of, and theoretical bases for, the heat transfer in the liquid layer and the partitioning of the sensible and latent heat and mass transfers across the interface under various conditions.
(*g*) Publications from related previous work available from correspondent.

ST. ANTHONY FALLS HYDRAULIC LABORATORY, UNIVERSITY OF MINNESOTA, Mississippi River at Third Avenue, S. E., Minneapolis, Minn. 55414. Dr. Roger E. A. Arndt, Director.

Inquiries concerning Projects 00111, 01168, 07677, and 10592 which are conducted by the Agricultural Research Service (see also project reports from U.S. Government laboratories; U.S. Department of Agriculture, Agricultural Research Service; North Central Region Project No. 01723) should be addressed to Fred W. Blaisdell, Research Leader, Hydraulics of Structures Research Unit, Agricultural Research Service, St. Anthony Falls Hydraulic Laboratory, at the above address.
Inquiries concerning Project 00194 should be addressed to John V. Skinner, Engineer in Charge, Federal Inter-Agency Sedimentation Project, St. Anthony Falls Hydraulic Laboratory at the above address.
Inquiries concerning all other projects should be addressed to Director, St. Anthony Falls Hydraulic Laboratory, at the above address.

149-0281W-060-36

MIXING AND DISPERSION AT A WARM WATER OUTLET

For summary, see Water Resources Research Catalog 11, 5.0349.

149-0285W-800-33

COMPUTER PROGRAMS AND SIMULATION MODELS IN WATER RESOURCES: SCOPE AND AVAILABILITY

For summary, see Water Resources Research Catalog **9**, 2.0623.

149-0437W-870-00

HYDRAULIC MODEL STUDIES OF ADDITIONS TO MAYFIELD HYDROPOWER PROJECT

For summary, see Water Resources Research Catalog **10**, 8.0098.

149-0438W-870-00

STOCHASTIC MODEL OF WATER TEMPERATURES IN STREAMS AND LAKES

For summary, see Water Resources Research Catalog **11**, 1.0027.

149-0439W-870-00

DEVELOPMENT OF METHODS TO SEPARATE SEDIMENTS FROM STORM WATER ASSOCIATED WITH CONSTRUCTION OPERATIONS

For summary, see Water Resources Research Catalog **11**, 2.0378.

149-00111-350-05

CLOSED CONDUIT SPILLWAY

(*b*) Agricultural Research Service, U.S. Dept. of Agric., in cooperation with the Minnesota Agric. Expt. Sta. and the St. Anthony Falls Hydraulic Laboratory.

(*d*) Experimental; generalized applied research for development and design.

(*e*) Recent work has been a model test of a closed tall two-way drop inlet with a crest section twice as long as the drop inlet and a structural transverse wall at the drop inlet midlength. The effect of these deviations from current design standards was determined and modifications suggested. Flow-induced vibrations were also investigated.

(*g*) The theory of closed conduit spillways has been developed, verified, and published. Results of tests on many forms of the closed conduit spillway entrance have been published. Pipe culverts laid on steep slopes may flow completely full even though the outlet discharges freely. Generalized methods for analysis and reporting of the results have been developed. The use of air as the model fluid has been verified by comparing test results with those obtained using water as the model fluid. The two-way drop inlet with the horizontal anti-vortex device causes the spillway to act as a self-regulating siphon when the headpool level approximates the anti-vortex plate elevation. The height of the anti-vortex plate above the drop inlet crest and the overhang of the anti-vortex plate determine the effectiveness of the plate as an anti-vortex device. For one form of the inlet, tests have been made to determine the crest loss coefficient, the barrel entrance loss coefficient, the pressures on the plate and the drop inlet, the general performance of the inlet, minimum and maximum permissible plate heights, and the head-discharge relationship for plate control. Variables have been the length of the drop inlet, the barrel slope, the height and overhang of the anti-vortex plate, and the sidewall thickness. Tests of low-stage orifices in the two-way drop inlet have shown that improper location and improper proportioning of the orifices can prevent priming of the spillway. The proper location and size of the orifices have been determined. To supplement the experiments, potential flow methods have been used to determine the theoretical coefficient of energy loss at the crest of the two-way drop inlet. Six shapes of elbow between the two-way drop inlet and the transition were tested. The elbows were evaluated on the basis of high minimum relative pressures and the presence of adverse pressure gradients. The theoretical free streamline elbow had small areas of adverse pressure gradient. The best elbow is an ellipse with semi-major and semi-minor axes of 2D and 1D. (D is the barrel diameter.) An elbow made up to two 45-degree circular segments of radii D/2 and 3D/2 also has generally satisfactory hydraulic characteristics. Seven transitions between the half-square crown, half-circular invert cross section at the elbow exit and the circular barrel were tested. The best transition is warped and 1D long. (See 1968 issue for details,–ed.) The entrance loss coefficients are low and identical within the limits of experimental precision for all elbow-transition combinations. Tests on the hood drop inlet have shown that the hood barrel entrance can be used to reduce the minimum required height of the drop inlet. Minimum sizes of drop inlet and anti-vortex devices have been determined. Undesirable performance of an operating spillway was traced to air-entraining hydraulic jumps in the barrel, inadequate size and debris-plugged air vents, and delayed venting from under the cover plate skirts that extended below the spillway crest. Adequate venting corrected the undesirable performance. This was achieved by removing a manhole cover in the cover plate. The manhole opening required an antivortex device and a trashrack. The point of termination of the transverse wall near the base of the drop inlet affects the flow in the two drop inlet shafts. Initial designs of the transverse wall resulted in unequal water levels in the two drop inlet shafts prior to priming, and caused submergence of the upstream and downstream crests at different respective stages. To eliminate this effect, the transverse wall should terminate 1D above the beginning of the elbow curvature, or the bottom of the transverse wall should be curved downstream.

(*h*) The following reports and papers are in various stages of completion:

Hydraulics of Closed Conduit Spillways–Part XVI.

Elbows and Transition for the Two-Way Drop Inlet; Part XVII.

The Two-Way Drop Inlet With a Semicylindrical Bottom.

Hydraulic Model Investigation of a Two-Way Drop Inlet for Floodwater Retarding Structure No. 3, Banklick Creek Watershed, Boone and Kenton Counties, Kentucky.

Hydraulics of Closed Conduit Spillways, Part XIII: The Hood Drop Inlet, K. Yalamanchili, F. W. Blaisdell, Agric. Res. Service, U.S. Dept. of Agric., *ARS-NC-23*, 78 pages, Aug. 1974.

Hydraulics of Closed Conduit Spillways, Part XIV: Antivortex Walls for Drop Inlets; Part XV: Low-Stage Inlet for the Two-Way Drop Inlet, C. A. Donnelly, F. W. Blaisdell, Agric. Res. Service, U.S. Dept. of Agric., *ARS-NC-33*, 37 pages, Mar. 1976.

Copies of these two publications may be obtained from the Agric. Res. Service, St. Anthony Falls Hydraul. Lab., at the above address.

The Two-Way Drop Inlet Self-Regulating Siphon Spillway, F. W. Blaisdell, C. A. Donnelly, K. Yalamanchili, *Proc. Design & Operation of Siphons & Siphon Spillways Symp.*, British Hydromechanics Research Assoc., *Paper C4*, pp. C4-31 to C4-53, 1975.

The Hood Drop Inlet Self-Regulating Siphon Spillway, F. W. Blaisdell, K. Yalamanchili, *Proc. Design & Operation of Siphons & Siphon Spillways Symp.*, British Hydromechanics Research Assoc., *Paper C-6*, pp. C6-69 to C6-88, 1975.

Theory of Flow in Long Siphons, F. W. Blaisdell, *Proc. Design & Operation of Siphons & Siphon Spillways Symp.*, British Hydromechanics Research Assoc., *Paper C7*, pp. C7-89 to C7-98, 1975.

The Hood Inlet Self-Regulating Siphon Spillway, F. W. Blaisdell, C. A. Donnelly, *Proc. Design & Operation of Siphons & Siphon Spillways Symp.*, British Hydromechanics Research Assoc., *Paper C11*, pp. C11-137 to C11-154, 1975.

149-00194-700-10

A STUDY OF METHODS USED IN MEASUREMENT AND ANALYSIS OF SEDIMENT LOADS IN STREAMS (Inter-Agency Sedimentation Project in cooperation with St. Anthony Falls Hydraulic Laboratory)

(*b*) Committee on Sedimentation, Water Resources Council; personnel of the U.S. Army Corps of Engrs. and the U.S. Geological Survey are actively engaged on the project.
(*d*) Experimental; applied research and development.
(*e*) Develop equipment and procedures to facilitate both the collection and analysis of sediment transported by natural streams. The project develops sampling equipment to meet special requirements then, as a service to all governmental organizations and to educational institutions, stocks, calibrates, and repairs sampling and analyzing equipment. Major equipment items stocked for resale include a single stage sampler, 4-, 22-, and 62-pound depth integrating samplers, 100-, 200-, and 300-pound electrically operated point-integrating samplers, and an intermittent pumping-type sampler. For the collection of bed material the project stocks piston-type hand operated samplers, 30-, and 100-pound scoop-type samplers. For particle size analysis the project can supply bottom-withdrawal tubes and visual-accumulation sedimentation tubes complete with recorders. The project's long-range objective is to develop an instrument to automatically record the concentration of suspended sediment transported by natural streams. Testing of bed-load samplers is scheduled to begin in 1978.
(*g*) To facilitate field sampling, the project is continuing to design light-weight suspended-sediment samplers that collect large-volume samples for sediment and chemical analysis. For automatic pump-samplers, reliable solid-state clocks have been designed to replace older mechanical clocks. A light-weight capacitive-discharge power supply for point-integrating samplers is now being produced. For basic research of large rivers, the project designed an instrumented body that contained a fathometer, a current meter, and an auxiliary compression-chamber to extend the depth range of point-integrating samplers. To facilitate particle-size analysis, an automated pipette withdrawal system was designed and tested. In cooperation with the St. Anthony Falls Hydraulic Laboratory staff, the project is preparing a facility for full scale tests of bed-load samplers.
(*h*) **A Study of Methods Used in Measurement and Analysis of Sediment Loads in Streams,** *Report U, An Investigation of a Device for Measuring the Bulk Density of Water-Sediment Mixtures,* J. P. Beverage, J. V. Skinner, 35 pages, Aug. 1974.
A catalog and numerous progress and letter reports are available upon request. Contact the District Engineer, St. Paul District, Corps of Engrs., 1135 U.S. Post Office and Custom House, St. Paul, Minn. 55101.

149-01168-350-05

A STUDY OF CANTILEVERED OUTLETS

(*b*) Agricultural Research Service, U.S. Dept. of Agric. in cooperation with Minnesota Agric. Expt. Sta. and St. Anthony Falls Hydraulic Laboratory.
(*d*) Experimental; generalized applied research for design.
(*e*) Pipe outlet conduits for small spillways are frequently cantilevered beyond the toe of the earth dam. Attempts are being made to determine quantitatively the size of the scour hole to be expected under various field conditions. Rectangular cantilever outlets with a deflector at the exit to throw the water away from the structure and move the scour hole further downstream are also scheduled for investigation.
(*g*) In earlier tests, material scoured from the hole deposited in the downstream channel and was left in place. These tests have been repeated with the scoured material continuously removed during the test, thus eliminating the deposit. Analysis of the data will begin soon.

149-07677-220-05

SCOUR AND PROTECTION AGAINST SCOUR AT STRUCTURES

(*b*) Agricultural Research Service, U.S. Dept. of Agric., in cooperation with the Minnesota Agric. Expmt. Sta. and the St. Anthony Falls Hydraulic Laboratory.
(*d*) Experimental; generalized applied research for development and design.
(*e*) Laboratory studies to determine for the box inlet drop spillway, the straight drop spillway, and the SAF stilling basin, the size and shape of the scour in sand beds and the size and placement of riprap to protect against scour.
(*f*) Suspended.

149-08993-300-05

HYDRAULICS OF ALLUVIAL CHANNELS–CHANNEL STABILITY AS RELATED TO CHANNELIZATION

(*b*) Agricultural Research Service in cooperation with the St. Anthony Falls Hydraulic Laboratory.
(*d*) Experimental and theoretical.
(*e*) The factors which lead to instability in river channels are being studied. Particular attention is being given to the processes of meandering and braiding, and to the hydraulic conditions necessary for the establishment of a channel of stable width. Experimental work is being conducted in initially straight model sand rivers, which are freely allowed to erode their banks and develop meandering or braided channels. The problem is also being investigated theoretically using, for example, stability analysis. The processes being studied in the laboratory are relevant in estimating the stability of channelized streams.
(*f*) Completed.
(*g*) The data obtained from these experiments are being combined with other laboratory and field data in order to test some theoretical developments. Preliminary results include new criteria for dividing river morphology into straight, meandering, and braided regimes, a critique of various methods for estimating meander length and an extension of tractive force theory to the case where stable banks coexist with sediment load.
(*h*) **The Flow and Stability Characteristics of Alluvial River Channels,** A. G. Anderson, G. Parker, A. Wood, Univ. of Minn., *St. Anthony Falls Hydraulic Lab. Proj. Rept. 161,* Sept. 1975.

149-08994-300-54

INVESTIGATION OF MEANDER SYSTEMS WITH SPECIAL REFERENCE TO THE DISCHARGE SPECTRUM

(*b*) National Science Foundation.
(*d*) Experimental and theoretical, Ph.D. thesis.
(*e*) Study was a continuation of a previous investigation conducted to ascertain the influence of the significant variables on the development of meander systems. Detailed measurements were made of the time development of meanders, to follow the development of the meander system in time.
(*f*) Completed.
(*g*) Meandering and braiding of alluvial rivers are complex phenomena. All variables appear to be interdependent and a river appears to be always in transition. Nevertheless, there must be a basic mechanism and certain primary factors governing the process. The development of a vertical fiber-optic probe initiated under a previous grant was completed under this grant. This probe is capable of automatically measuring the bed profile and greatly facilitating experimental procedure. Both experimental and analytical work with a specific emphasis on determining the influence of the hydrograph on the meandering process were carried out.
The experiments essentially confirmed the analytical postulate that meandering is determined by the bankful flow and is independent of lower flows. Other analytical results concerning the stability criteria and the meander wave length were also confirmed by the experiments.

(*h*) **On the Cause and Characteristic Scales of Meandering and Braiding in Rivers,** G. Parker, *J. Fluid Mechanics* **76**, 3, pp. 457-480, 1976.
Modeling of Meandering and Braiding in Rivers, G. Parker, A. G. Anderson, presented *2nd Ann. Symp. Modeling Techniques for Waterways, Harbors, and Coastal Engrg.*, San Francisco, Sept. 3-5, 1975. To be published in a Proceedings.

149-08995-870-73

STUDY OF COOLING WATER DISCHARGE EFFECTS ON WINTER CONDITIONS IN MINNESOTA

For summary, see Water Resources Research Catalog **10**, 2.0221.

149-08996-210-54

THE MECHANISM OF TURBULENCE IN STEADY HELICAL PIPE FLOW

(*b*) National Science Foundation.
(*d*) Experimental, basic, Ph.D. thesis.
(*e*) An experimental study of the basic mechanics of turbulence and turbulent shear stress distribution in flow in helically corrugated pipes was undertaken. Measurements were taken to relate velocity profiles and friction factors to turbulence characteristics and to study the properties of three-dimensional boundary layers. The experimental work was conducted in a 12-inch diameter helical pipe using air as the fluid and hot-film anemometer equipment was used to measure turbulent fluctuations, energy spectra and shear stress in the flow.
(*f*) Suspended (data taking completed).
(*g*) An analysis of the measurements of pressure distribution across the rotational flow in a helical pipe shows that the influence of turbulence is practicably negligible.
(*h*) Discussion based on above result will appear in *ASME, J. Fluids Engrg.*, June 1977.

149-08997-480-44

STOCHASTIC ANALYSIS OF METEOROLOGICAL DATA IN THE UPPER MIDWEST

(*b*) National Oceanic and Atmospheric Administration.
(*d*) Applied research; Doctoral thesis.
(*e*) Provide a stochastic analysis or model of meteorological and hydrological data during the spring flood period in the Upper Midwest for use with digital simulation models.
(*f*) Completed.
(*g*) During the first quarter a statistical analysis of temperature and precipitation data at St. Cloud, Minnesota was undertaken. The following resulted: 1) the temperature data were stabilized, 2) it was concluded that temperature and precipitation could be treated as independent variables, 3) the deterministic component of temperature was computed, 4) auto-correlation, partial auto-covariance and spectra of the stochastic component of temperature were computed, 5) parameters of the Markov chain were estimated for each period for precipitation, and 6) the parameters of gamma distribution were estimated.
(*h*) **Stochastic Analysis of Spring Meteorological Data in the Upper Midwest,** K. Kim, C. E. Bowers, *St. Anthony Falls Hydraulic Lab. Proj. Rept. 156*, June 1975.

149-08998-220-47

FILM INVESTIGATION OF THE CAUSES OF FAILURE OF THE BIG SIOUX BRIDGE

(*b*) Federal Highway Administration.
(*d*) Field and laboratory investigation.
(*e*) A training film was prepared for use by the Federal Highway Administration. It includes footage of an investigation of the causes of failure of the river crossing conducted in the laboratory and field films taken by the Federal Highway Administration after the failure and during a subsequent flood to delineate the flow pattern through the structure. The film incorporates additional scenes showing the nature of scour around piers, a discussion of the parameters influencing the scour, and illustrate the hydraulic factors that influenced the failure.
(*f*) Completed.
(*h*) **Investigation of the Causes of Failure of the Big Sioux Bridge,** *St. Anthony Falls Hydraulic Lab. Film No. 92*, 1975.

149-08999-350-75

STABILITY TESTS OF DAM SEALING MATERIAL

For summary, see Water Resources Research Catalog **10**, 8.0251.

149-09000-430-75

HYDRAULIC MODEL STUDIES OF THAMES RIVER, CONNECTICUT PIER

For summary, see Water Resources Research Catalog **10**, 8.0031.

149-10592-350-05

FLOW-INDUCED VIBRATIONS IN TWO-WAY DROP INLETS

(*b*) Agricultural Research Service, U.S. Dept. of Agric., in cooperation with the Minnesota Agric. Expmt. Sta. and the St. Anthony Falls Hydraulic Laboratory.
(*d*) Experimental; basic and generalized applied research for development and design.
(*e*) Determine if fluctuating hydrodynamic forces generated by flows in two-way drop inlets are sufficiently intense to cause destructive structural vibration or if they merely produce acoustical noise. Develop a generalized analytical model and computer program for qualitatively and quantitatively predicting the vibration of models or prototypes. Develop means of minimizing or eliminating objectionable pulsating forces and/or flow-generated noise in these structures.

149-10593-390-70

HYDRAULIC MODEL STUDIES OF GENESEE RIVER INTERCEPTOR, S.E. DROPSHAFT STRUCTURES

(*b*) Chas H. Sells Construction Engineers.
(*d*) Laboratory investigations to develop optimum dropshaft design.
(*e*) Examine the hydraulic characteristics of a vertical dropshaft model. Particular attention being focused on air entrainment in the vertical dropshaft, air release, and energy dissipation in a sump at the bottom of the shaft, air venting back to the ground surface, and flow conditions in the exit conduit to the storage tunnels.
(*f*) Suspended.

149-10594-540-75

TESTS OF SOUND SUPPRESSION WATER SYSTEMS

(*b*) Reynolds, Smith & Hills Architects-Engrs-Planners (NASA subcontract).
(*d*) Theoretical and experimental applied research.
(*e*) For noise suppression, NASA space shuttle launchings will require delivery of 200,000 gals of water in 20 seconds from an elevated storage tank to a spray nozzle system surrounding the rocket engines. A 1 to 10 model of the flow system was studied and larger models of the nozzles were tested.
(*f*) Completed.
(*g*) The studies clarified and improved the system and procedures to eliminate critical water hammer and cavitation problems. Nozzle spray patterns were evaluated.
(*h*) **Hydraulic Flow Studies For the Elevated Water Tank of a Sound Suppression Water System,** J. F. Ripken, J. M. Wetzel, W. Q. Dahlin, J. E. Ferguson, C. S. S. Song, *St. Anthony Falls Hydraulic Lab. Memo. No. 138*, Oct. 1976.
Hydraulic Transient Flow Studies for a Sound Suppression Water System, J. M. Wetzel, C. S. S. Song, J. F. Ripken, J.

254-330 O - 78 - 10

E. Ferguson, W. Q. Dahlin, *St. Anthony Falls Hydraulic Lab. Memor. No. 139*, Dec. 1976.
Hydraulic Model Studies of the Spray Nozzles for a Sound Suppression Water System, J. M. Wetzel, J. F. Ripken, *St. Anthony Falls Hydraulic Lab. Memor. No. 143*, Mar. 1977.

149-10595-710-70

DYE DILUTION EVALUATION

(*b*) FMC Corporation.
(*d*) Experimental applied research.
(*e*) A validation of the precision of flow measurement by fluorescent dye-dilution techniques was undertaken at the Laboratory by comparing volumetrically measured flows over the range of 50,000 to 80,000 GPM. Subsequently, the method was applied in a field acceptance test of a large variable speed vertical turbine pump handling effluent from a wastewater treatment plant.
(*f*) Completed.
(*g*) Results of the validation tests were demonstrated to be within 3 percent of volumetrically determined flows and the field application of the dye-dilution method for determining hydraulic performance was shown to be within 1.5 percent of the predicated head-capacity pump curve.
(*h*) **Validation of Use of Dye-Dilution Method for Flow Measurement in Large Open and Closed Channel Flows,** W. Morgan, D. Kempf, R. E. Phillips, *Proc. NBS Flow Measurement Symposium, Gaithersburg, Md., SP-484*, Feb. 23-25, 1977.

149-10596-720-13

PREPARATION OF DESIGNS AND DRAWINGS FOR A BEDLOAD SEDIMENT CALIBRATION FLUME AT ST. ANTHONY FALLS HYDRAULIC LABORATORY

(*b*) St. Paul District Corps of Engineers.
(*d*) Experimental and design.
(*e*) Design a flume in the St. Anthony Falls Hydraulic Laboratory for the purpose of testing bedload samplers.
(*f*) Completed.
(*g*) A design has been completed which would permit the calibration of full scale bedload samplers with coarse bed materials. The existing 9 ft wide main laboratory channel would be fitted with sediment traps, a system for continuously measuring the rate of bedload transport and a sediment recirculating system. The facility would be capable of handling sediment material with D_{50} of up to 64 mm and transport rates of up to 5 lb/ft-sec. Funds for construction and maintenance of the facility have been provided by the U.S. Geological Survey.

149-10597-220-13

AN INVESTIGATION OF THE BED REGIME OF ALLUVIAL CHANNELS AS INFLUENCED BY SUBMERGED GROINS

(*b*) St. Paul District, Corps of Engineers.
(*d*) Experimental, applied research.
(*e*) Experimental studies were conducted to determine the dynamic equilibrium depth of scour associated with submerged constrictions or groins. Tests were carried out with various groin geometries in both rigid- and movable-bed models. Velocity traverses were made over the groins and in the constricted region to establish the relationship between the ratio of discharge through the constriction to the total discharge and the relative groin submergence and geometry.
(*f*) Completed.
(*g*) Measurements of the eroded bed profile in the constricted region indicated that the equilibrium relative depth of scour was related primarily to the discharge ratio and the constriction ratio. All groin geometries tested demonstrated the capability of providing relatively large scour depths at low stages, and less scour depths at high stages for which a larger portion of the total discharge passed over the groins. Reasonable agreement with predicted relative scour depth was noted for the relatively large sediment transport rates used in the study.
(*h*) **Model Studies of the Bed Regime of Alluvial Channels as Influenced by Submerged Groins,** S. Dhamotharan, W. Q. Dahlin, J. M. Wetzel, *St. Anthony Falls Hydraulic Lab. Project Rept. 159*, Mar. 1976.

149-10598-720-70

HYDRODYNAMIC DESIGN OF LABORATORY WAVE FACILITIES

(*b*) MTS Systems Corporation.
(*d*) Experimental; hydrodynamic design.
(*e*) Experimental investigations were carried out to determine the wave making characteristic of a two-hinged, flap type random wave generator to be used at the U.S. Naval Academy. A design for a wave absorber with low reflection coefficients over a wide range of wave conditions was also developed.
(*f*) Completed.
(*g*) The proposed wave generator design proved to meet the design specifications. The final design of the wave absorber consisted of an impermeable plate of discontinuous slope, overlain with a permeable layer of square bars providing a porosity of about 70 percent. Reflection coefficients of less than ten percent were measured over the design wave spectrum.

149-10599-870-60

DIFFUSER FOR STORM SEWER OUTLET

(*b*) Minnesota Department of Transportation.
(*d*) Experimental; design.
(*e*) A 12 ft diameter tunnel will carry a stream plus storm water runoff from an interstate highway into the Mississippi River just below St. Anthony Falls where regulated river depth is about 10 ft to the sandstone bed. River traffic enroute to a lock entrance passes close to the bank where the outlet will be located. The outlet must be designed to not interfere with barge traffic, especially during maximum flood discharges when the tunnel velocity is as much as 15 fps.
(*f*) Completed.
(*g*) A diffuser in the horizontal plane consisting essentially of four 7-1/2° channels with baffle blocks at the channel entrances fulfilled the requirements.
(*h*) **Hydraulic Study for Storm Sewer Outlet,** E. Silberman, *St. Anthony Falls Hydraulic Lab. Project Rept. 166*, Mar. 1977.

149-10600-210-70

FRICTION FACTORS FOR HELICAL ALUMINUM PIPES WITH RE-CORRUGATED ANNULAR END RINGS

(*b*) Kaiser Aluminum and Chemical Sales Company.
(*d*) Experimental; design.
(*e*) Evaluate effect of joint connectors on friction factors for flow in helically corrugated pipes.
(*f*) Completed.
(*g*) Connectors cause a small additional loss in head per pipe length, of the order of 5 percent. The major problem is leakage at the connectors. If enough care is taken to prevent leakage, the same effort can also reduce frictional loss at the connectors.
(*h*) **Further Studies of Friction Factors for Helical Corrugated Aluminum Pipes with Re-Corrugated Annular Rings on Each End,** W. Q. Dahlin, E. Silberman, *St. Anthony Falls Hydraulic Lab. Project Rept. 160*, Apr. 1976.

149-10601-350-75

GURI PROJECT FINAL PHASE: HYDRAULIC MODEL FABRICATION

(*b*) Harza Engineering Company.
(*d*) Design and construction.
(*e*) Provide expertise in the form of assistance and supervision of local personnel in the construction of the Guri model (Venezuela) involving machine ship work; steel fabrications and piping work; carpentry work; and concrete and masonry work.

149-10602-870-75

RECIRCULATING CONDENSER WATER FOR A COOLING TOWER

(*b*) Sverdrup and Parcel and Associates.
(*d*) Experimental; design.
(*e*) The collecting basin beneath a circular plan form, natural draft cooling tower will also be used as a storage basin for cooling water. An investigation was made of the relationship between water depth in the basin and in the pump bay as influenced by connecting channel design for given tower support pedestals (some of which must stand in the basin outlet) and pumping rates.
(*f*) In progress at end of 1976.
(*g*) Channel configuration and pedestal streamlining are being designed to meet storage and pumping criteria.
(*h*) **Hydraulic Model Studies For A Cooling Tower Circulating Water System, Callaway Plant Unit–Union Electric Company,** E. Silberman, W. Q. Dahlin, *St. Anthony Falls Hydraulic Lab. Project Rept. 167*, Apr. 1977.

149-10603-390-75

TRANSIENT ANALYSIS STUDIES

(*b*) Lozier Engineers.
(*d*) Theoretical, applied research.
(*e*) Construct a mathematical model of the Culver-Goodman and Cross-Irondequoit Tunnels, Rochester, N.Y., flow system and run it for various operating conditions.
(*g*) The transient two-phase flow model developed for the Culver-Goodman Tunnel is being expanded and applied to a larger system including Cross-Irondequoit Tunnel. The model is being used for the purpose of optimum design and control of the system.
(*h*) **Hydraulic Transient Analysis for the Culver-Goodman Tunnel, Rochester, New York,** C. S. Song, T. M. Ring, A. C. H. Young, K. S. G. Leung, *St. Anthony Falls Hydraulic Lab. Project Rept. No. 157*, Dec. 1975.
Two-Phase Flow Hydraulic Transient Model for Storm Sewer Systems, C. S. Song, *2nd Intl. Conf. Pressure Surges*, London, Sept. 1976.
Interfacial Boundary Condition in Transient Flows, C. C. S. Song, *Advances in Civil Engrg. Through Engrg. Mechanics, 2nd Ann. Conf., Engrg. Mech. Div., ASCE*, May 1977.

149-10604-860-36

WATER TEMPERATURE STUDIES AT THE MONTICELLO FIELD STATION

(*b*) Environmental Protection Agency.
(*d*) Project involves field measurements, theoretical analysis, and development of a numerical model for temperature prediction in a narrow channel.
(*e*) Study conducted to provide information on the temperature characteristics encountered in the Monticello Field Channels. The channels are used for ecological experiments.
(*g*) A numerical model for water temperature distribution in the MFS channels has been developed. Convective and evaporative heat transfer through the water surface, as well as longitudinal dispersion were studied. A wind speed function and a longitudinal dispersion value were derived by analysis of weather and water temperature and weather data.
(*h*) In preparation.

149-10605-350-75

CALUMET PUMPING STATION HYDRAULIC MODEL STUDY

(*b*) DeLeuw, Cather and Company.
(*d*) Experimental; applied.
(*e*) A hydraulic model study was conducted for the underground storm water pumping station to be built in Chicago. Air entrainment, entrainment of fuel from oil spills, grit transport, and head losses were investigated.
(*f*) Completed June 1977.
(*g*) The design of the structure was modified in two places. It then performed satisfactorily with respect to the above four elements.
(*h*) **Calumet Pumping Station Hydraulic Model Study,** H. Stefan, A. Wood, *St. Anthony Falls Hydraulic Lab. Project Rept. No. 164*, May 1977.

149-10606-870-73

HEAT TRANSFER STUDIES AT BLACK DOG LAKE

(*b*) Northern States Power Company, Minneapolis, Minn.
(*d*) Analytical, numerical and field investigation; applied research.
(*e*) Study relates to the operation and possible redesign of a cooling pond for an electric power generation plant. The effectiveness of the pond, which has been in operation for many years, was evaluated by numerical modeling and analysis of field data.
(*f*) Completed.
(*g*) The cooling pond was found to dissipate in the average 60 percent of the plant's waste heat. Flow conditions through the pond could be improved to increase waste heat dissipation. Predicted effluent temperatures were found to agree very well with measured ones for the summer months. Density stratification was found to develop in the winter.
(*h*) **Waste Heat Dissipation and Effluent Water Temperatures from Black Dog Lake,** H. Stefan, C. V. Nguyen, *St. Anthony Falls Hydraulic Lab. Project Rept. 162*, July 1976.

149-10607-440-73

STURGEON LAKE STUDY

(*b*) Northern States Power Company, Minneapolis, Minn.
(*d*) Analytical and numerical: applied research with some basic elements.
(*e*) The exchange of water between the Mississippi River mainstem and Sturgeon Lake near Red Wing, Minnesota was investigated. The Prairie Island Nuclear Power Generating Plant is located in the vicinity of Sturgeon Lake. Flow rates past the cooling water intake and past the cooling water outlet were determined from a numerical model.
(*f*) Completed.
(*g*) The flow past the power plant through a series of backwater channels was found to depend on river flow rates and weather. The predictive model developed will be used in plant operation and monitoring.
(*h*) **Analysis of Flow Through Sturgeon Lake and Backwater Channels of Mississippi River Pool No. 3 Near Red Wing, Minnesota,** H. Stefan, K. Anderson, *St. Anthony Falls Hydraulic Lab. Project Rept. 165*, Apr. 1977.

STEVENS INSTITUTE OF TECHNOLOGY, Davidson Laboratory, Castle Point Station, Hoboken, N. J. 07030. Dr. John P. Breslin, Director.

151-08980-520-21

ANALYSIS OF THE PNEUMATIC-HYDRODYNAMIC EFFECTS ATTENDING OSCILLATORY HEAVING OF SURFACE-EFFECT SHIPS

(*b*) David Taylor Naval Ship Research and Development Center.
(*c*) C. H. Kim, S. Tsakonas, Chief, Fluid Dynamics Division.
(*d*) Theoretical; applied.
(*e*) Ascertain the relationship between plenum pressure and heave amplitude at any Froude number. In this study the presence of the vehicle is simulated by a pressure patch of oscillatory nature of constant amplitude moving uniformly at the free surface of a three-dimensional flow field. Analysis has been developed to evaluate the waves generated by a uniformly moving oscillatory surface-effect ship.
(*h*) **Waves Generated by Uniformly Moving Oscillatory Surface Effect Ship,** *Davidson Laboratory Letter Report 1874*.

151-08981-520-21

ANALYSIS OF THE AERODYNAMICS OF THE CHAMBER OF A WATERBORNE AIR CUSHION CRAFT

(*b*) David Taylor Naval Ship Research and Development Center.
(*c*) S. Tsakonas, Chief, Fluid Dynamics Division, W. R. Jacobs and M. R. Ali.
(*d*) Theoretical; applied.
(*e*) Two mathematical models simulating air-cushion supported vehicles have been studied analytically. The models have the form of an inverted box equipped with a system of fans for continuous supply of air to the chamber and with openings of variable area near the interface for the outflow. Velocity potential functions for the perturbed flow field have been determined analytically and a computer program adapted to a high-speed digital computer has been developed, furnishing information on the mean and first harmonic of the pressure in the chamber and on the resulting forces and moments.
(*f*) Completed.
(*g*) Systematic calculations indicate a spatial variation of the pressure in the plenum such as detected in the tests when the vehicle is moving in head seas and is free to heave and pitch. Reasonable agreement has been exhibited between theoretical predictions of pressures and heaving motion and experimental values.
(*h*) **Plenum Pressure of an Air-Cushion Supported Vehicle,** *Davidson Laboratory Report 1902.*

151-08983-550-21

COUNTER-ROTATING PROPELLERS IN A SPATIALLY VARYING THREE-DIMENSIONAL FLOW FIELD: LOADING AND THICKNESS EFFECTS

(*b*) David Taylor Naval Ship Research and Development Center.
(*c*) S. Tsakonas, Chief, Fluid Dynamics Division, W. R. Jacobs and M. R. Ali.
(*d*) Theoretical; applied.
(*e*) The linearized usteady lifting surface theory has been applied to the evaluation of blade loadings and hydrodynamic forces and moments of counterrotating propeller systems with equal and unequal number of blades operating in uniform and nonuniform inflow fields, both units rotating with the same RPM. The mathematical model takes into account as realistically as possible the geometry of the propulsive device, the mutual interaction of both units and the three-dimensional spatially varying inflow field. The thickness effects have been taken into account by utilizing the "thin body" approach. A computer program has been developed adaptable to high-speed digital computers (CDC6600-7600) for counterrotating propulsive systems of equal and unequal blade number in uniform inflow due to the loading and thickness effects.
(*f*) Completed.
(*h*) **Steady and Unsteady Loadings and Hydrodynamic Forces on Counterrotating Propellers,** *Davidson Lab. Rept. 1899*, presented *11th Symp. Naval Hydrodynamics*, London, Apr. 1976.

151-08984-550-21

PROPELLER BLADE PRESSURE DISTRIBUTION DUE TO LOADING AND THICKNESS EFFECTS

(*b*) David Taylor Naval Ship Research and Development Center.
(*c*) S. Tsakonas, Chief, Fluid Dynamics Division, W. R. Jacobs and M. R. Ali.
(*d*) Theoretical; applied.
(*e*) A theoretical approach is developed and computational procedure adaptable to a high speed digital computer is established for the evaluation of the blade pressure distribution of a marine propeller due to loading and thickness when operating in a nonuniform inflow field. The analysis treats both design and off-design conditions in steady-state and unsteady flows with the proper selection of chordwise modes.
(*f*) Completed.
(*g*) The numerical solution yields the blade loading and resulting hydrodynamic forces, moments, blade bending moments and the blade pressure distribution on both faces (suction and pressure sides). Predicted results compare well with those of experiments.
(*h*) *Davidson Laboratory Report 1869.*

151-08985-520-54

LATERAL STABILITY DERIVATIVES OF A SHIP IN SHALLOW WATER

(*b*) National Science Foundation, Engineering Division,
(*c*) S. Tsakonas, Chief, Fluid Dynamics Division, C. H. Kim, H. Eda and W. R. Jacobs.
(*d*) Theoretical and experimental; applied research.
(*e*) The theoretical part treats the solution of an integro-differential equation, which determines the local lateral speed along the hull provided the hull geometry, water depth and Froude number (depending on water depth) are all specified. An analytical method for the evaluation of the "blockage" parameter is established and a program adapted to CDC6600 or 7600 high speed digital computer has been developed, furnishing: a) blockage parameters, b) local lateral speed, c) significant hydrodynamic coefficients of the equations of motion in the lateral and rotational modes. A systematic set of experiments were conducted for the Series 60 with $C_B = 0.60$ and a full tanker of 250,000 DWT. Results of these experiments, as well as those of Fujino's and Norrbin's, and some of a proprietary nature, have been compared with theoretical predictions. The comparisons show varying degrees of agreement from poor to satisfactory, depending on the nature of the hydrodynamic coefficients and very much on the depth-draft ratio.
(*f*) Completed.
(*g*) The comparisons of theoretical results with experimental information show varying degrees of agreement from poor to satisfactory, depending on the nature of hydrodynamic coefficients and very much on the depth-draft ratio.
(*h*) *Davidson Laboratory Report 1905.*

151-08988-520-22

STUDY OF THE APPLICATION OF THE FUNCTIONAL POLYNOMIAL INPUT-OUTPUT MODEL TO ADDED RESISTANCE IN WAVES

(*b*) Naval Sea Systems Command, General Hydromechanics Research Program.
(*c*) J. F. Dalzell.
(*d*) Analytical, applied research.
(*e*) Attempt synthesis in the time domain of the long period fluctuations of added resistance.
(*f*) Completed.
(*g*) Demonstrate by means of analyses of experimental data that a functional polynomial model for added resistance in waves is an adequate engineering approximation. The results obtained indicate that this is so. It was demonstrated that it is possible to identify the quadratic frequency response function for added resistance from experiments in both irregular and periodic waves; and that, given the frequency domain response, it is possible to synthesize at least the nonlinear low frequency resistance components in the time domain.
(*h*) **Application of the Functional Polynomial Model to the Ship Added Resistance Problem,** J. F. Dalzell, *11th Symp. on Ship Hydrodynamics*, University College, London, Apr. 1976.

151-10035-550-20

INTERMITTENT CAVITATION ON HYDROFOILS IN TRAVELING GUSTS

(*b*) Office of Naval Research, Fluid Dynamics Branch.
(*c*) T. R. Goodman, Senior Staff Scientist and J. P. Breslin, Director.
(*d*) Theoretical; applied research.
(*e*) Ship propellers develop intermittent cavitation on each blade as they pass through the region of reduced velocity

in the region of 12 o'clock abaft the hull. To determine the blade sectional behaviors, a theory for two-dimensional partially cavitating hydrofoils is being developed to determine cavity geometry, lift and drag. This solution will ultimately be used as the inner solution to be matched to an outer, three-dimensional theory for the cavitating propeller blade. Coupled integral equations have been reduced to equations which must be solved numerically by use of a computer.

151-10036-550-21

MODIFICATION OF THEORY FOR PROPELLER UNSTEADY LOADING AND FORCES TO ACCOUNT FOR SHIP MEAN WAKE AND MEAN PROPELLER INDUCTION

(*b*) David Taylor Naval Ship Research and Development Center.
(*c*) S. Tsakonas, Chief, Fluid Dynamics Division and W. R. Jacobs.
(*d*) Theoretical; applied.
(*e*) Modify the existing analysis and corresponding program for the evaluation of propeller unsteady loading and forces to account for the ship mean wake and mean propeller induction, also to perform systematic calculations and compare these with the results of the presently available method and with experimental measurements.

151-10037-630-21

A THEORY AND COMPUTER PROGRAM FOR VIBRATORY FORCES OF PUMP-JETS

(*b*) David Taylor Naval Ship Research and Development Center.
(*c*) S. Tsakonas, Chief, Fluid Dynamics Division, W. R. Jacobs and M. R. Ali.
(*d*) Theoretical; applied.
(*e*) To develop a theory and corresponding program for the evaluation of the unsteady loading distribution on all lifting surfaces of a pump-jet propulsive unit and the resulting vibratory forces and moments exerted on the system.

151-10038-520-45

PROPELLER-GENERATED VIBRATORY HULL FORCES AND MOMENTS

(*b*) Office of Maritime Technology–Maritime Administration.
(*c*) S. Tsakonas, Chief, Fluid Dynamics Division and J. P. Breslin, Director, Davidson Laboratory.
(*d*) Theoretical; applied.
(*e*) Develop a theoretical approach and corresponding computer program to evaluate the propeller-induced vibratory forces on a hull. The Hess-Smith program will be utilized in conjunction with the propeller-induced velocity field program to evaluate the source strengths representing the hull in the presence of the propeller. Then by application of the extended Lagally theorem, the hydrodynamic forces and moments are determined. In addition, the forces and moments due to the propeller pressure field in which the hull is immersed, is also evaluated and thus the total hydrodynamic forces and moments are determined.

151-10039-420-54

WAVE REFRACTION CAUSED BY HORIZONTAL SHEAR FLOWS

(*b*) National Science Foundation–Engineering Division.
(*c*) C. H. Kim, S. Tsakonas and H. T. Chen.
(*d*) Theoretical; applied research.
(*e*) A theory will be established for the refraction of a wave train caused by the presence of a horizontal shear flow by using the Green's function techniques in conjunction with the "small parameter" expansion method. The theory will be evaluated for a series of shear flow modes.

151-10040-520-22

ESTIMATION OF THE SPECTRUM ON NON-LINEAR SHIP ROLLING

(*b*) Naval Sea Systems Command, General Hydromechanics Research Program.
(*c*) J. F. Dalzell.
(*d*) Analytical, applied research.
(*e*) Apply functional polynomial input-output model to the nonlinear single degree of motion ship rolling equation.
(*f*) Completed.
(*g*) In the equation of the nonlinear model to the conventional ship rolling equation analytic coefficients are required. A mixed linear plus cubic approximation was found reasonable as a replacement for the usual quadratic damping representation, and there were indications that the model may be more generally valid than had been thought. Expressions for the roll spectrum through terms of fifth degree nonlinearity were developed and partially evaluated. Comparisons with previously simulated results indicated that the functional polynomial model approach might be practical with some further developments.
(*h*) **A Note on the Form of Ship Roll Damping,** J. F. Dalzell, *SIT-DL-76-1887*, Davidson Lab.. Stevens Inst. Tech., May 1976.
Estimation of the Spectrum of Non-Linear Ship Rolling: The Functional Series Approach, *SIT-DL-76-1984*, Davidson Lab., Stevens Inst. Tech., May 1976.

151-10041-590-22

FEASIBILITY OF WAVE PULSE TECHNIQUES FOR EXPERIMENTAL DETERMINATION OF ADDED RESISTANCE

(*b*) Naval Sea Systems Command, General Hydromechanics Research Program.
(*c*) J. F. Dalzell.
(*d*) Analytical and computational, applied research.
(*e*) Investigate the possibility that, by exploiting the properties of the functional polynomial model for added resistance, a practical wave pulse experimental technique can be developed.
(*f*) Completed.
(*g*) Attention was concentrated upon possible techniques involving only one wave pulse run. No promising technique was found. It appears that there is not enough information in a single resistance transient to enable the identification of any part of the quadratic frequency response function from a single transient experiment.
(*h*) **A Study of the Feasibility of Wave Pulse Techniques for Experimental Determination of Added Resistance,** J. F. Dalzell, *SIT-DL-76-1928*, Davidson Lab., Stevens Inst. Tech., Dec. 1976.

151-10042-590-22

ANALYTICAL INVESTIGATION OF THE QUADRATIC FREQUENCY RESPONSE FOR ADDED RESISTANCE

(*b*) Naval Sea Systems Command, General Hydromechanics Research Program.
(*c*) J. F. Dalzell and C. H. Kim.
(*d*) Analytical, applied research.
(*e*) Develop and verify method for computation of the quadratic frequency response function for added resistance.
(*f*) Completed.
(*g*) Analytical and experimental estimates of the quadratic frequency response function were found to be in good qualitative agreement and fair quantitative agreement. Many of the existing experimental estimates of the function are thought to be of low accuracy so that there seems reasonable evidence that it is feasible to make hydrodynamic estimates of the quadratic frequency response function required for the prediction of nonlinear fluctuations of resistance in random seas.
(*h*) **Analytical Investigation of the Quadratic Frequency Response for Added Resistance,** J. F. Dalzell, C. H. Kim,

SIT-DL-76-1878, Davidson Lab., Stevens Inst. Tech., Aug. 1976.

TEXAS A&M UNIVERSITY, Department of Civil Engineering, College Station, Tex. 77843. Dr. John B. Herbich, Professor and Head, Coastal, Hydraulic and Ocean Engineering Group.

152-07708-410-44

SCOUR OF GULF COAST SAND BEACHES DUE TO WAVE ACTION IN FRONT OF SEA WALLS AND DUNE BARRIERS

(*b*) National Oceanic and Atmospheric Administration, Sea Grant Project.
(*c*) Professor R. E. Schiller, Jr.
(*d*) Experimental, applied research; Master's thesis and Ph.D. dissertation.
(*e*) A series of transient beach scour tests are being carried out on a laboratory wave tank using beach slopes of 1:40, 1:50 and 1:70 to arrive at beach scour profiles under various wave conditions. A computer program is being used in an attempt to measure shallow water wave reflection coefficients.
(*f*) Completed.
(*h*) **Scour of Gulf Coast Beaches Due to Wave Action,** C. B. Chesnutt, R. E. Schiller, Jr., *Offshore Technology Conf., Paper No. 1352*, 1971.
Experimental Studies of Beach Scour Due to Wave Action, W. O. Song, *C.O.E. Rept. 166, TAMU-SG-73-211*, Texas A&M Univ., 1973.
Experimental Studies of Beach Scour, W. O. Song, R. E. Schiller, *ASCE Hydraulics Specialty Conf.*, Aug. 1977.

152-08311-870-48

AN INVESTIGATION OF THE EFFECTS OF CURRENTS AND WAVES ON A FLOATING OIL SLICK RETAINED BY A BARRIER

(*b*) United States Coast Guard.
(*c*) Dr. L. A. Hale, Dept. of Mech. Engrg., Dr. D. R. Basco, Dept. of Civil Engineering.
(*d*) Experimental, basic and applied research, M.S. and Ph.D. theses.
(*e*) Investigate the individual and combined effects of surface gravity waves and currents on the behavior of an oil slick.
(*f*) Completed.
(*g*) Empirical equations developed to estimate set-up of oil slick by waves only and to predict oil entrainment in currents as a function of oil properties and flow field.
(*h*) **The Effects of Currents and Waves on an Oil Slick Retained by a Barrier,** L. A. Hale, D. J. Norton, C. A. Rodenberger, *USCG, DOT-CG-23327A*, Dec. 1974.
An Investigation of the Effects of Progressive Waves on an Oil Slick Retained by an Absorber Beach, Y.-M. Huang, *M.S. Thesis*, Texas A&M, Aug. 1973.

152-09047-420-13

EFFECTS OF CURRENT ON CHARACTERISTICS OF GRAVITY WAVES

(*b*) Texas A&M University and U.S. Army Engineers Waterways Experiment Station.
(*c*) Dr. J. B. Herbich and Dr. L. Z. Hales.
(*d*) Experimental and analytical research.
(*e*) Changes occur in the characteristics of surface waves propagated in a region of streaming water. The velocity field of the wave motion interacts with the velocity distribution of the current pattern. The effect of the nonuniform current on the rate of energy propagation through the inlet was investigated by combining the results of the experiments with previously developed theoretical work. It was found that under certain specific conditions both flood and ebb currents enabled the waves to propagate more energy through the inlet than in the absence of a current as a result of the interaction of the two velocity fields.
(*f*) Completed.
(*h*) **Effects of a Steady Nonuniform Current on the Characteristics of Surface Gravity Waves,** L. Z. Hales, J. B. Herbich, *Misc. Paper H-74-11*, U.S. Army Engr. Waterways Exp. Station, Dec. 1974.
The Influence of Tidal Inlet Currents on the Propagation of Wave-Energy into Estuaries–Physical Model Indications, L. Z. Hales, J. B. Herbich, *Intl. Symp. River Mechanics*, Intl. Assoc. for Hydraulic Research, pp. C15-1-12, Bangkok, Thailand, 1973.
Tidal Inlet Current–Ocean Wave Interaction, L. Z. Hales, J. B. Herbich, *Proc. 13th Coastal Engrg. Conf.*, Chapter 36, pp. 669-688, Vancouver, B.C:, Canada, 1972.

152-09048-590-22

THREE-DIMENSIONAL RESPONSE OF DEEP WATER LINES IN STEADY STATE FLOWS

(*b*) Naval Facilities Engineering Command.
(*c*) Dr. Richard F. Dominguez, Dept. of Civil Engineering.
(*d*) Theoretical and experimental; applied research.
(*e*) A systematic study of cable parameters in relation to deep water mooring applications under three-dimensional steady state loading conditions has been made. Included in this study are both negatively and neutrally buoyant cables in water depths from 5 to 25 thousand feet. A finite element model cable was used to predict three-dimensional configuration, cable reactions and internal stress distribution in the cable under directional hydrodynamic loading conditions.
(*f*) Completed.
(*g*) A systematic study of various hydrodynamic cable loading models indicated that the choice of loading criteria is rather arbitrary. Results are presented which permit direct evaluation of three-dimensional cable configurations and reactions for cables of arbitrary geometry, diameter and weight in currents up to one knot.
(*h*) **Three-Dimensional Response of Deep Water Mooring Lines in Steady State Flows,** R. F. Dominguez, G. E. Owens, *Texas A&M Univ. Rept. COE-157*, Dec. 1972.

152-09049-590-00

HYDRODYNAMIC FORCES ON CABLES SUBJECT TO FREQUENCY VARIED MOTION

(*c*) Dr. Richard F. Dominguez, Assoc. Professor, Dept. of Civil Engineering.
(*d*) Experimental and theoretical; basic research.
(*e*) The dependency of hydrodynamic forces under unsteady, oscillatory conditions is studied with respect to the behavior of a highly flexible cable subjected to forced motion in a fluid. Experimental investigation is supplemented with the use of a finite element model of a cable structure.
(*g*) Results to date show that significant errors are possible by using classical descriptions based on the steady state derived added mass and drag coefficients for part of the cyclic loading history.
(*h*) **Hydrodynamic Forces on Cables Subject to Frequency Varied Motion,** R. W. Haas, R. F. Dominguez. Presented *16th Cong. Intl. Assoc. Hydraul. Res.*, San Paulo, Brazil, Aug. 1975.

152-09050-220-44

SCOUR AROUND OFFSHORE PIPELINES

(*b*) National Oceanic and Atmospheric Administration.
(*d*) Master's theses.
(*e*) Determine through physical modeling, the effect of storm waves on buried pipelines approaching and crossing the shoreline. Scour depth and scour patterns have been evaluated in a two-dimensional wave tank and future tests will be conducted in a wave basin to evaluate three-dimensional effects. Analysis of two-dimensional data indicates relationships between scour depth and wave height; scour length and wave length; and wave height and wave length/water depth for a range of wave steepness values. Estimates of burial depth have been made and are being

verified experimentally. Rock cover is also considered in an effort to reduce burial depth. Forces on partially buried pipelines are measured in a laboratory wave channel.

(*h*) **Factors Influencing Equilibrium of a Model Sand Beach,** D. C. Smith IV, J. B. Herbich, *TAMU-SG-77-203*, Texas A&M Univ., 1976.

Scour Around Model Pipelines Due to Wave Action, J. B. Herbich, Honolulu, Hawaii, 1976.

Wave-Induced Scour Around Offshore Pipelines, J. B. Herbich, *Off-shore Technology Conf., OTC 2968*, Houston, Tex., 1977.

152-09051-420-44

WAVE INDUCED PRESSURE FIELDS AROUND A BURIED PIPELINE

(*b*) National Oceanic and Atmospheric Administration, Sea Grant Program.

(*c*) Dr. Richard F. Dominguez, Assoc. Professor, Dept. of Civil Engineering.

(*d*) Theoretical and experimental; applied research.

(*e*) Numerical computer models using both the finite difference and finite element technique were developed to simulate the interaction of a two-dimensional wave system with a submerged pipeline and its surrounding soil media. Both computer models were validated by comparison with existing analytical and experimental results defining the pressure distribution in the soil media without a pipeline. Models are being used to study possible liquification failure phenomena and to establish rational criteria for designing offshore pipelines.

(*h*) **Numerical Solutions for Determining Wave-Induced Pressure Distributions Around Buried Pipelines,** N. W. Lai, R. F. Dominguez, Texas A&M Univ., *Sea Grant Rept. TAMU-SG-75-204*, Dec. 1974.

152-09052-490-44

DEVELOPMENT AND ANALYSIS OF COMPUTER MODELS OF HYDRAULIC PIPELINE DREDGE

(*b*) Center for Dredging Studies, Sea Grant (NOAA).

(*c*) Dr. David R. Basco, Associate Professor.

(*d*) Theoretical, applied research.

(*e*) A computer based model of a hydraulic pipeline dredge and system has been developed to study the relative importance of many variables involved (pump design, sediment size, etc.) on the solids output for various pumping distances (horsepower limitation) and digging depths (cavitation limitation). The model can be used to predict optimum solids production for any given hydraulic-pipeline dredging operation. In addition, problems associated with field studies of hydraulic dredges have been identified and a field research program proposed to obtain field data to validate the results of the computer model.

(*g*) Preliminary comparisons between model-results and limited field data show good agreement. Pump design can be one of the most important variables in output of similar dredges.

(*h*) **Systems Engineering and Dredging–The Feedback Problem,** D. R. Basco, *Sea Grant Publication TAMU-SG-74-204*.

Parameter Study of Variables Affecting the Performance of a Hydraulic Pipeline Dredge Model, D. R. Basco, *Proc. 7th Dredging Seminar, CDS Rept. 181, Sea Grant Rept. TAMU-SG-75, 1975.*

An Experimental and Theoretical Study of the Flow Field Surrounding a Suction Pipe Inlet, W. J. Apgar, D. R. Basco, *Sea Grant Publication TAMU-SG-74-203; Texas A&M Thesis* by W. J. Apgar.

Analytical Model of Hydraulic Pipeline Dredge, D. R. Basco, *J. Waterways, ASCE* **101,** WW1, Feb. 1975.

Feedback from Field Studies of Hydraulic Dredges, D. R. Basco, *J. Waterways, Harbors and Coastal Engrg. Div., ASCE* **101,** WW3, Aug. 1975.

152-09053-490-00

METHODS FOR OFFSHORE DREDGING

(*b*) Center for Dredging Studies, Texas A&M University.

(*c*) Dr. J. B. Herbich, Dr. Y. K. Lou, Ocean Engineering Program.

(*d*) Conceptual design.

(*e*) Conventional, river cutterhead dredges are not designed for operation in open waters under wave conditions. There is a need for development of seaworthy pipeline dredges capable of operating in waves up to 6 feet in height. Several different catamaran twin-hulls are evaluated for possible use to provide a stable platform for offshore dredging.

(*h*) **Methods for Offshore Dredging,** J. B. Herbich, *Proc. 6th World Dredging Conf.*, Taipei, Taiwan, 1974.

Stable Catamaran Hulls for Cutterhead Dredges, J. B. Herbich, Y. K. Lou, *Offshore Technology Conf., OTC 2290*, 1975.

Catamarans for Offshore Dredging, J. B. Herbich, Y. K. Lou, *The Work Boat*, 1975.

152-09054-370-47

PAVEMENT AND GEOMETRIC DESIGN CRITERIA FOR MINIMIZING HIGHWAY HYDROPLANING

(*b*) Federal Highway Administration, Office of Research and Development.

(*c*) Professor B. M. Gallaway, D. D. L. Ivey, Dr. W. D. Ledbetter, Dr. H. E. Ross, Jr., Dr. R. E. Schiller, Jr., Dr. Don Woods.

(*d*) Study of literature and reanalysis of previous Texas A&M University data on water films, hydroplaning, skid resistance. Use of computer program HVOSM to study vehicle control. Investigation of surface drainage criteria of the various State Highway Departments.

(*e*) A study involving required texture for portland cement concrete pavement surfaces to minimize hydroplaning; partial and full dynamic hydroplaning of vehicle tires; required texture and cross-slope combinations for asphalt concrete surfaces; the relationship of pavement cross slope to vehicle control; the hydraulic flow phenomena of thin films of water on pavement surfaces and under tires; and deficiencies in existing surface drainage design methodology for sag vertical curves.

(*f*) Phase I part of study to be completed in April 1975. Phase II to start Spring 1975.

(*g*) Phase I, draft submitted to project sponsor. Revised final report, Phase I to be submitted April 1975.

(*h*) **Pavement and Geomatrice Design Criteria for Minimizing Highway Hydroplaning, Phase I, Final Report,** *Federal Highway Admin. Rept. No. FHWA-RD-74*, Office of Res. and Dev., Washington, D. C. 20590, about July 1975.

152-09055-220-44

INVESTIGATIONS OF THE SPREAD AND EROSION OF UNCONFINED DREDGE SPOIL MOUNDS

(*b*) NOAA, Sea Grant Program; Corps of Engineers, Office of Dredged Material Research.

(*c*) Dr. David R. Basco, Assoc. Professor.

(*d*) Field and analytical, applied research, M.S. and Ph.D. theses.

(*e*) A field investigation was conducted to determine the rate and extent of spread of unconfined, maintenance (silt) material in Galveston Bay, Texas, adjacent to the Gulf Intracoastal Waterway (GIWW). A review of previous dredging histories (quantities, locations, times, etc.) is also in progress together with a study of the local environment in an attempt to identify the sources of sediment contributing to shoaling problems in the waterway. It is desired to develop the capability to predict the rate at which dredged material, placed adjacent to dredged channels, will return to the channel due to gravity spreading, local currents and wind and wave erosion of the material. This information is desired to assess spoil disposal alternatives on a sound economic basis. Additional field studies and hydraulic model, sediment transport investigations are planned to correlate time scales for spoil island erosion between field and hydraulic model results.

(*g*) In the completed field study in Galveston Bay, immediately following deposition, over 40 percent of the spoil left the designated spoil area and spread out over the bay floor primarily as a mud-density current. Eventually spoil covered an area three-times larger than the original spoil area. Return of the spoil to the newly dredged channel was not significant during the study period primarily because of the presence of a submerged dike along the channel and the tidal direction.

(*h*) **Field Study of an Unconfined Spoil Disposal Area of the GIWW in Galveston Bay, Texas,** D. E. Bassi, D. R. Basco, *Sea Grant Rept. TAMU-SG-74-208; Texas A&M M.S. Thesis*, D. E. Bassi.
Assessment of the Factors Controlling the Long-Term Fate of Subaqueous Spoil Banks, D. R. Basco, A. H. Bouma, W. A. Dunlap, Army Corps of Engrs..Contract. No. C-0129, Jan. 1975.

152-09056-030-00

THE EFFECT OF VISCOSITY ON THE DYNAMICS OF A SUBMERGED SPHERICAL SHELL

(*c*) Dr. Jack Y. K. Lou, Dept. of Civil Engineering.
(*d*) Theoretical; basic.
(*e*) The axisymmetric vibrations of a spherical shell immersed in a compressible, viscous fluid are studied. The dynamic response of the shell is determined by the classical normal mode method while a boundary layer approximation is employed for the fluid medium.
(*g*) It is found that for free oscillation, fluid viscosity may produce noticeable effects on the damping components of the complex natural frequencies and is particularly important for the non-radiating modes. For forced vibrations, the present study reveals that the contribution of viscous effect is of small order, except in the vicinity of peak shell responses.
(*h*) **The Effect of Viscosity on the Dynamics of a Submerged Spherical Shell,** T.-C. Su, Y. K. Lou, presented *Vibrations Conf., ASME*, Sept. 17-19, 1975.

152-09058-420-00

FORCES DUE TO WAVES ON SUBMERGED STORAGE TANKS

(*c*) Dr. J. B. Herbich.
(*d*) Experimental and analytical research.
(*e*) The existing theories describing wave forces on large submerged structures have been reviewed. Inertial forces are predominant on submerged structures which have the principal dimension equal to or larger than the vertical dimension. Wave forces on model submerged structures were determined experimentally and results for geometrically simple structures were obtained.
(*h*) **Forces Due to Waves on Submerged Structures,** G. E. Shank, J. B. Herbich, *NOAA, Sea Grant, TAMU-SG-70-212*, Texas A&M Univ., 1970.
Wave Forces on Models of Submerged Offshore Structures, P. E. Versowsky, J. B. Herbich, NOAA, Sea Grant, *TAMU-SG-72-215*, Texas A&M Univ., 1975.
Wave Forces on Underwater Storage Tanks, J. B. Herbich, *Tech. Bull. No. 74-4*, Texas Engrg. Experiment Station, Texas A&M Univ., 1974.

152-10577-470-70

SURGE ATTENUATION AT BARGE SLIP HARBOR AT HARBOR ISLAND FABRICATION YARD

(*b*) Brown & Root, Inc., Houston, Tex.
(*c*) Dr. J. B. Herbich and Dr. Y. K. Lou, Ocean Engineering Program.
(*d*) Experimental, field and laboratory.
(*e*) An experimental investigation on the wave and surge motions in a barge slip harbor along the Corpus Christi ship channel. Field measurements indicated surges as high as four feet with a period from 2-4 minutes. Laboratory experiments were conducted to evaluate various wave and surge attentuation devices for different slip entrance configurations. Three alternatives were suggested including timing of barge loading operations, complete temporary blockage of slip entrance and bottom pontoon support for the barge.
(*f*) Completed.
(*h*) **Surge Attenuation at Barge Slip Harbor at Harbor Island Fabrication Yard,** J. B. Herbich, Y. K. Lou, *Rept. No. COE-190*, Ocean Engrg. Program, Texas A&M Research Foundation, 1976.

152-10578-330-82

ANALYSIS OF THE ROLE OF THE GULF INTRACOASTAL WATERWAY IN TEXAS

(*b*) Texas Ports Association, Texas Coastal and Marine Council, NOAA Sea Grant Program.
(*c*) J. Miloy, et al.
(*d*) The Gulf Intracoastal, an integral artery in the water transportation system of Texas, extends 426 miles along the coast. A continuing problem of the Corps of Engineers is disposal of dredged materials. Both upland disposal sites and deep ocean dumping are considered too costly; and securing diked dredged material disposal sites in the adjacent coastal area may even be more expensive due to ownership and environmental considerations. The study comprises six tasks: environmental implications, engineering aspects, sociological characteristics, economic impact, funding alternatives, legal aspects.
(*f*) Completed.
(*h*) **Summary Report: Analysis of the Role of the Gulf Intracoastal Waterway in Texas,** *TAMU-SG-75-203*, Texas A&M Univ., 1975.
Analysis of the Role of the Gulf Intracoastal Waterway in Texas, *TAMU-SG-75-202*, Texas A&M Univ., 1975.
Engineering Aspects of Maintenance of the Gulf Intracoastal Waterway in Texas, J. B. Herbich, *Proc. 7th World Dredging Conf., WODCON VII*, San Francisco, 1976.

152-10579-330-10

PREDICTION OF THE BEHAVIOR OF DEEP-DRAFT VESSELS IN RESTRICTED WATERWAYS

(*b*) U.S. Army Corps of Engineers.
(*c*) Dr. J. B. Herbich.
(*d*) Applied research.
(*e*) Deep-draft navigation channel analysis, design and review is based on empirically-derived ratios of the design vessel's dimensions. Because of the radical changes in vessel operational purposes and characteristics, these ratios can no longer be safely or economically applied. The objective of this research is to develop a mathematical model which will provide the engineer with a comprehensive tool in the design and review of deep-draft navigation channels. The model will estimate values of squat, bank suction forces and moments, equilibrium drift and rudder angles and heights of ship-generated waves for varied channel configurations, ship positions and ship velocities.

152-10580-330-00

SEDIMENT MOVEMENT INDUCED BY SHIPS IN RESTRICTED WATERWAYS

(*c*) Dr. J. B. Herbich.
(*d*) Applied research.
(*e*) A numerical model utilizing the momentum theory of the propeller and Shields' diagram is being developed to study sediment movement induced by a ship's propeller in a restricted waterway. The velocity distribution downstream of the propeller is simulated by the Gaussian normal distribution function and the shear velocity and shear stress were obtained using Sternberg's formulas.
(*h*) **Sediment Movement Induced by Ships in Restricted Waterways,** Y. C. Lou, J. B. Herbich, *TAMU-SG-76-209*, Texas A&M Univ., 1976.

152-10581-230-00

INFLUENCE OF THE SUPRAMOLECULAR MARINE ENVIRONMENT ON PITTING CORROSION

(*c*) Dr. D. B. Harris, B. M. Gallaway and Dr. J. B. Herbich.
(*d*) Theoretical research.
(*e*) Process of corrosion pit nucleation in the marine environment is being investigated.
(*f*) Completed.
(*g*) Rupture of the passive film is described in terms of its sensitivity to attack by negatively hydrated ions. A corollary is suggested which describes the inhibiting effect of various positively hydrated ions. The role of marine microorganisms is being evaluated as it relates to those environmental modifications that may contribute to pit nucleation.
(*h*) **Influence of the Supramolecular Marine Environment on Pitting Corrosion,** D. B. Harris, B. M. Gallaway, J. B. Herbich, *TAMU-SG-76-211*, Texas A&M Univ., 1976.

152-10582-490-44

OFFSHORE MINING TECHNOLOGY

(*b*) Marine Board, Assembly of Engineering, National Research Council and NOAA.
(*c*) Dr. J. B. Herbich, Ocean Engineering Program.
(*d*) Applied research, planning.
(*e*) The study was to identify, assess and evaluate the technological needs for mining of hard minerals in both territorial and international waters. Of particular interest in this part of the study was the evaluation of sand, gravel and shell mining.
(*g*) Present methods of recovering sand, gravel and shell have been reviewed and recommendations will be made to improve efficiency and lessen the environmental impact.
(*h*) **Recovery of Sand, Gravel and Shell From the Ocean,** a brief summary of Technology Development Projects Sponsored by NOAA, *CDS Rept. No. 191*, Center for Dredging Studies, Texas A&M Univ., Mar. 1976.

152-10583-330-44

ENVIRONMENTAL CONSIDERATIONS OF THE OPERATION AND MAINTENANCE OF THE TEXAS GULF INTRACOASTAL WATERWAY

(*b*) Sea Grant.
(*c*) Dr. Wesley P. James, Civil Engineering Department.
(*d*) Applied research.
(*e*) Study provides baseline environmental information from literature reviews and a field sampling program. It gives a basic understanding of the environmental aspects of intracoastal waterway transportation system including evaluation of activities directly associated with waterway and the potential of the waterway to transport pollutants from one area of the coast to another.
(*f*) Project completed January 1977.
(*g*) Poor water quality in the channel was generally associated with fresh water inflows. A model was developed to evaluate the flow between Galveston Bay and Sabine Lake. Satellite imagery of the Lower Laguna Madre was used to evaluate flow patterns in bays. High shoaling rates were located where the prevailing flow patterns crossed the channel.
(*h*) Final report.

152-10584-810-33

POTENTIAL IMPACT OF THE DEVELOPMENT OF LIGNITE RESERVES ON WATER RESOURCES OF EAST TEXAS

(*b*) Office of Water Resources Research.
(*c*) Dr. Wesley P. James.
(*d*) Applied research.
(*e*) Project was concerned with identifying potential adverse effects of lignite strip mining and lignite utilization on the hydrology and water quality of the area. Both field and desk studies were conducted to evaluate the potential impact of lignite development on water resources of the area. Field studies included (1) monthly water sampling for a one-year period of streams, lakes and wells near the strip-mined areas at Fairfield and Rockdale and at control stations located away from the lignite development; (2) leaching studies of the lignite and overburden at Fairfield and Rockdale; (3) precipitation samples collected under the airborne waste plume from the lignite-fueled electric generating plant at Fairfield; and (4) a limited trace element enrichment study in the soils around the plant at Fairfield.
(*f*) Project completed August 1976.
(*g*) Strip mining can change the hydrologic characteristics of the area and full development of the near-surface lignite reserves in east and east central Texas could have a significant impact on the groundwater resources of the region.
(*h*) Final report.

152-10585-800-33

ENVIRONMENTAL EVALUATION OF WATER RESOURCES DEVELOPMENT

(*b*) Office of Water Research and Technology.
(*c*) Dr. Wesley P. James.
(*d*) Applied research.
(*e*) The environmental effects of channelization and surface impoundments are discussed for twelve physiographic regions of Texas as delineated on black and white satellite (LANDSAT-1) mosaic of band 7. With the aid of LANDSAT-1 imagery, representative or typical transects were chosen within each region. Profiles of each site were constructed from topographic maps and environmental data were accumulated for each site and related to low altitude aerial photography and enlarged LANDSAT-1 false color composites.
(*f*) Project completed July 1976.
(*g*) Each diagrammatic transect, with accompanying data and photographs, provides significant information for input of environmental amenities on a local and regional scale into preliminary water resources development studies. The utilization of the transects provides a visual display of available information, aids in the identification and inventory of resources, assists in the identification of data gaps and provides a planning tool for additional data acquisition.
(*h*) Final report.

152-10586-330-44

SHOALING CHARACTERISTICS OF THE GULF INTRACOASTAL WATERWAY IN TEXAS

(*b*) Sea Grant.
(*c*) Dr. Wesley P. James, Civil Engineering Department.
(*d*) Applied research.
(*e*) Maintenance dredging records were used to compute average shoaling rates in 5000-foot reaches for the entire Texas Gulf Intracoastal Waterway. Environmental data pertinent to the waterway were gathered from published and unpublished sources. Computed shoaling rates and selected environmental features were plotted on Composite Factors Maps. Similar reaches were grouped and examined using analysis of variance techniques to determine the effect of selected environmental factors on shoaling rates. A model was also developed to predict shoaling rate in a reach with known environmental factors.
(*f*) Project completed May 1976.
(*g*) The average shoaling rate over the entire waterway was found to be 10.5 inches per year. Shoaling in open bay areas was found to be an average of 3 inches per year greater than in land-cut areas. The combination of dredged material mounds, or fetch greater than 5 miles, with water depths less than 6 feet (surrounding bay depth) increased average shoaling rates 5 inches per year. The placement of dredged material in mounds on the windward side of the waterway increased the average shoaling rate of open bay areas by 7 inches per year. In bay areas with long fetches and depths less than three feet, it was found that windward placement of dredged material was actually advantageous. Hurricanes did not appear to have a drastic impact on shoaling rates; however, localized effects were noted in several areas.

(*h*) Final report.

152-10587-870-43

ENVIRONMENTAL CONSIDERATIONS OF BRINE DISPOSAL

(*b*) Federal Energy Administration.
(*c*) Dr. Wesley P. James.
(*d*) Applied research.
(*e*) Pursuant to the requirements of the Energy Policy and Conservation Act of 1975, the Federal Energy Administration proposes to implement the Strategic Petroleum Reserve. One hundred fifty million barrels of oil are to be stored by December 22, 1978, in the Early Storage Reserve, and at least 500 MMB are to be stored by December 22, 1982, under the full program. Among the storage options studied, the most attractive from an economic and environmental standpoint is storage in solution-mined salt cavities near existing petroleum distribution facilities along the Gulf of Mexico coast. Water quality is one of the most critical among the sensitive environmental issues and large quantities of raw water will be required and large quantities of brine will be produced in the construction and operation modes of solution-mined caverns. Disposal of brine into the sea is an alternative being considered for seven of the sites.
(*f*) Project will be completed September 1, 1977.
(*g*) Strategic Petroleum Reserve Workshop was held on the Environmental Considerations of Brine Disposal near Freeport, Texas. Site specific reports are being prepared by several sites along the Gulf.
(*h*) Workshop proceedings.

152-10588-330-00

MAJOR PORT IMPROVEMENT ALTERNATIVES FOR THE TEXAS COAST

(*c*) Dr. J. B. Herbich, J. W. Berriman, Ocean Engineering Program.
(*d*) Applied research.
(*e*) With the advent in recent years of very large commercial craft (VLCC) and ultra large commercial craft (ULCC), the U.S. ports have fallen behind many other maritime countries in providing suitable docking facilities.
(*g*) Ship channel design criteria have been reviewed in terms of minimum width and depth requirements for various size vessels. Improved channel designs are considered for the ports of Port Arthur, Galveston, Freeport and Corpus Christi, Texas.
(*h*) **Major Port Improvement Alternatives for the Texas Coast,** J. W. Berriman, J. B. Herbich, *TAMU-SG-77-205*, 1977.

152-10589-430-00

BENEFICIAL USES OF DREDGED MATERIALS

(*b*) Center for Dredging Studies.
(*c*) Dr. J. B. Herbich and Mr. B. S. Hubbard, Ocean Engineering Program.
(*d*) Applied research, documentation.
(*e*) A review of an international list of publications was made to gather examples of locations where dredged material was put to a productive use. Mail questionnaires revealed about 143 sites where dredged material, as a by-product of maintenance of capital dredging, was put to productive use. The classifications were commercial, industrial, recreational, wildlife habitats, agricultural, hydraulic control, transportation, future and research, and miscellaneous.
(*g*) Analysis of results to-date indicate the commercial and industrial uses to be the most prevalent. Maintenance dredging generated the material for most of the sites. Sound planning for the disposal of material generated from each dredging project has become a necessary consideration.
(*h*) **Productive Land Use of Dredged Material Containment Areas: International Literature Review,** B. S. Hubbard, J. B. Herbich, *CDS Report No. 199*, Center for Dredging Studies, TEES, Texas A&M Univ., 1977.

152-10590-590-00

APPLICATION OF THE FINITE ELEMENT METHOD TO TOWED CABLE DYNAMICS

(*c*) Dr. Y. K. Lou, J. Ketchman.
(*d*) Basic, theoretical.
(*e*) Project deals with towing an object through a fluid by means of a cable. For a slender, neutrally buoyant towbody, the planar configuration of the towed system is determined for steady motion and for time-dependent maneuvers of the towing vehicle. A formulation of the finite element method that applies to towed cable dynamics is presented including bending deformation and stretch of the elements, and nodal forces caused by acceleration, distributed weight, and hydrodynamic loading. Although based on established forms for fluid drag, the treatment and expressions for nodal hydrodynamic loading forces are new. The resultant system of equations for the unknown nodal displacements is solved by step-by-step integration in time using a scheme that eliminates troublesome longitudinal oscillations. Lumped and distributed systems are compared with respect to the treatment of mass and hydrodynamic loading and the effects of bending stiffness are illustrated.
(*f*) Completed.
(*h*) **Application of the Finite Element Method to Towed Cable Dynamics,** J. Ketchman, Y. K. Lou, *Proc. Ocean 1975 Conf.*, pp. 98-107, Sept. 1975.

152-10591-350-75

MODEL TESTS OF SPILLWAY AND STILLING BASIN, COLETO CREEK DAM, NEAR VICTORIA, TEXAS

(*b*) Forrest and Cotton, Dallas, Tex.
(*c*) Dr. John B. Herbich and Dr. R. E. Schiller, Jr., Professors of Civil and Ocean Engineering.
(*d*) Experimental.
(*e*) The testing program involved testing of a two-dimensional model (three bays of a total of seven) on a 1/50-scale of the spillway, tainter gates and low Froude number stilling basin to establish the design of piers, length of stilling basin and placement of blocks in the stilling basin. A three-dimensional model (1/100-scale) was then tested at flow rates up to a prototype value of 306,000 cfs to establish proper design of the approaches to the spillway. The three-dimensional model (except the spillway and stilling basin) was constructed of fiberglas over hardware cloth.
(*f*) Experimental work completed. Preparation of report in progress.

TEXAS A&M UNIVERSITY, College of Geosciences, Dept. of Oceanography, College Station, Tex. 77843. Dr. Worth D. Nowlin, Jr., Professor and Department Head.

153-09914-420-54

APPLICABILITY OF QUASI-LONG WAVE EQUATIONS TO NUMERICAL MODELING OF DISPERSIVE WAVES IN TWO DIMENSIONS

(*b*) National Science Foundation.
(*c*) R. O. Reid and A. C. Vastano.
(*d*) Theoretical applied research.
(*e*) A numerical algorithm based on the Korteweg-DeVries type equations in one and two horizontal coordinates and time are employed to investigate both dispersive and nondispersive gravity wave phenomena including tsunamis and modification of solitary waves over variable topography and reflection from vertical walls for oblique angles of incidence.
(*g*) A study has been completed of the spectral response around the coasts of the Hawaiian Islands to a broad band wave input from the Aleutian source region for frequencies in the tsunami range. Studies are underway of the effect of an irregular "bumpy" bottom on the modification

of tsunamic waves. Also studies are in progress on the numerical simulation of Mach stem phenomena produced by reflection of a solitary wave from a vertical wall of oblique angles of incident and of refraction and reflection of solitary waves moving obliquely over an inclined sea bed and over a step.

(*h*) **Numerical Computation of Tsunami Response for Island Systems,** E. N. Bernard, A. C. Vastano, *J. Phys. Oceanogr.*, 1977 (in press).

153-09915-420-44

INVESTIGATION OF TSUNAMI RESPONSE SPECTRA IN THE HAWAIIAN ISLANDS

(*b*) National Oceanic and Atmospheric Administration/Environmental Research Laboratories.
(*c*) A. C. Vastano.
(*d*) Applied research.
(*e*) The numerical model employed in the study by Bernard and Vastano referenced above (see 09914) will be employed to determine the spectral response for a set of many directions of incident tsunami waves for the coasts of the Hawaiian Islands.
(*g*) Refinements are in progress of the radiation condition to be employed in the numerical model before extensive runs are carried out.
(*h*) None. Project started in March 1977.

153-09916-450-44

DEVELOPMENT OF A DEPTH-VARYING CURRENT PREDICTION MODEL FOR THE GULF COAST

(*b*) Sea Grant.
(*c*) J. C. H. Mungall, R. E. Whitaker.
(*d*) Applied research.
(*e*) Program and compare results of three long wave Hydrodynamic Numerical Models that provide three-dimensional current information. The methods are based on those of J. J. Leendertse, N. S. Heaps, C. P. Jelesnianski.
(*g*) The three finite-difference schemes have been tested in simple applications and are currently being prepared for application to more general cases.
(*h*) Reports describing use of the three programs will be available from Texas A&M Sea Grant Office, Sept. 1977.

153-09917-420-11

STORM SURGE SIMULATION IN TRANSFORMED COORDINATES

(*b*) Coastal Engineering Research Center.
(*c*) R. O. Reid, A. C. Vastano, and R. E. Whitaker.
(*d*) Theoretical applied research.
(*e*) Develop a two-dimensional time dependent numerical storm surge model employing orthogonal curvilinear coordinates. The coordinate system is based on a conformal mapping of the interior region bounded by the coast, 180 m depth contour, and two parallel lateral boundaries.
(*f*) Completed.
(*g*) Three regions of the continental shelf of the Gulf of Mexico and two regions of the eastern seaboard of the United States have been mapped. The model is used to simulate the surge inducted by Hurricanes Carla (1961), Camille (1969), and Gracie (1959). Computed and observed water levels are compared.
(*h*) **Storm Surge Simulation in Transformed Coordinates, Vol. I. Theory and Application,** J. J. Wanstrath, R. E. Whitaker, R. O. Reid, A. C. Vastano, Coastal Engrg. Res. Center, Dept. of the Army, *Ref. 76-3*, Nov. 1976.

TEXAS A&M UNIVERSITY, Texas Water Resources Institute, College Station Tex. 77843. Dr. J. R. Runkles, Institute Director.

154-0383W-820-33

ATTITUDES AND PUBLIC PARTICIPATION ON THE HIGH PLAINS TOWARD GROUNDWATER PLANNING AND MANAGEMENT INSTITUTIONS

(*b*) OWRT.
(*c*) Dr. Frank Baird, Texas Tech University, Lubbock, Tex. 79409.
(*e*) See WRRC 10, 4.0057.

154-0385W-800-33

INSTITUTIONAL CONSTRAINTS AND CONJUNCTIVE MANAGEMENT OF WATER RESOURCES IN WEST TEXAS

(*b*) OWRT.
(*c*) Dr. Otis Templer, Texas Tech University, Lubbock, Tex. 79409.
(*e*) See WRRC 10, 3.0101.

154-0386W-820-33

SIMULATION OF POLLUTANT MOVEMENT IN GROUNDWATER AQUIFERS

(*b*) OWRT.
(*c*) Dr. Donald Reddell.
(*e*) See WRRC 10, 4.0056.

154-0387W-870-33

TREATMENT OF WOOD PRESERVING WASTEWATER

(*b*) OWRT.
(*c*) Dr. Tom Reynolds.
(*e*) See WRRC 10, 5.0668.

154-0388W-820-33

ECONOMIC EFFECTS OF LAND SUBSIDENCE DUE TO EXCESSIVE GROUNDWATER WITHDRAWAL IN THE TEXAS GULF COAST AREA

(*b*) OWRT.
(*c*) Dr. Lonnie Jones.
(*e*) See WRRC 10, 6.0090.

154-0389W-840-33

THE EFFECTS OF CHANGING INPUT AND PRODUCT PRICES ON THE DEMAND FOR IRRIGATION WATER IN TEXAS

(*b*) OWRT.
(*c*) Dr. Ronald Lacewell.

154-0390W-840-33

ESTIMATION OF THE ECONOMIC DEMAND FOR IRRIGATION ON THE HIGH PLAINS AND RIO GRANDE PLAIN REGIONS OF TEXAS

(*b*) OWRT.
(*c*) Dr. Bruce Beattie.

154-0391W-870-33

DESIGN AND DEMONSTRATION OF A NON-CONVENTIONAL DENITRIFICATION SYSTEM

(*b*) OWRT.
(*c*) Dr. Robert Sweazy, Texas Tech University, Lubbock, Tex. 79409.

154-0392W-800-33

LEGAL ASPECTS OF LAND USE REGULATION OF LAKE SHORELANDS BY STATE AND LOCAL GOVERNMENTS FOR THE PROTECTION OF LAKES

(*b*) OWRT.

(*c*) Dr. Corwin Johnson, University of Texas, Austin, Tex. 78712.

154-0393W-840-33

THE IMPACT OF ENERGY SHORTAGE ON IRRIGATION IN THE HIGH PLAINS AND TRANS PECOS REGIONS OF TEXAS

(*b*) OWRT.
(*c*) Dr. Ronald Lacewell.

154-0394W-800-33

OPTIMAL USE OF GROUNDWATER AND SURFACE WATER TO REDUCE LAND SUBSIDENCE

(*b*) OWRT.
(*c*) Dr. Donald Reddell.

154-0395W-820-33

HEAT TRANSPORT IN GROUNDWATER SYSTEMS

(*b*) OWRT.
(*c*) Dr. Donald Reddell.

154-0396W-810-33

EVALUATION OF THE IMPACT OF TEXAS LIGNITE DEVELOPMENT ON TEXAS WATER RESOURCES

(*b*) OWRT.
(*c*) Dr. C. C. Mathewson.

154-0397W-840-33

NEW IRRIGATION SYSTEM DESIGN FOR MAXIMIZING IRRIGATION EFFICIENCY AND INCREASING RAINFALL UTILIZATION

(*b*) OWRT.
(*c*) Dr. William Lyle.

154-0398W-880-33

PROBLEMS OF PUBLIC ACCESS TO WATER IN TEXAS LAKES AND STREAMS: AN ANALYSIS

(*b*) OWRT.
(*c*) Dr. Otis Templer, Texas Tech University, Lubbock, Tex. 79409.

154-0399W-810-33

METHODOLOGY FOR ANALYZING EFFECTS OF URBANIZATION ON WATER RESOURCE SYSTEMS

(*b*) OWRT.
(*c*) Dr. Larry Mays, University of Texas, Austin, Tex. 78712.

154-0400W-800-33

SYSTEMATIC ANALYSIS OF PRIORITY WATER RESOURCES PROBLEMS TO DEVELOP A COMPREHENSIVE RESEARCH PROGRAM FOR THE SOUTHERN PLAINS RIVER BASIN REGION

(*b*) OWRT.
(*c*) Dr. J. R. Runkles.

154-0401W-840-33

INFLUENCE OF TRICKLE IRRIGATION ON THE QUALITY OF IRRIGATION RETURN FLOW

(*b*) OWRT.
(*c*) Dr. Kirk Brown.
(*e*) See WRRC **9,** 5.1561.

154-0402W-820-33

ADJUSTMENTS DUE TO A DECLINING GROUNDWATER SUPPLY: HIGH PLAINS OF NORTHERN TEXAS AND WESTERN OKLAHOMA

(*b*) OWRT.
(*c*) Dr. Ronald Lacewell.

154-0404W-820-33

INSTITUTIONAL ARRANGEMENTS FOR EFFECTIVE GROUNDWATER MANAGEMENT TO HALT LAND SUBSIDENCE

(*b*) OWRT.
(*c*) Dr. Lonnie Jones.

154-0405W-410-33

IMPACT OF WATER RESOURCE DEVELOPMENT ON COASTAL EROSION, BRAZOS RIVER, TEXAS

(*b*) OWRT.
(*c*) Dr. C. C. Mathewson.

154-0406W-800-33

ANALYSIS OF PRIORITY WATER RESOURCES FOR THE SOUTHERN PLAINS REGION

(*b*) OWRT.
(*c*) Dr. J. R. Runkles.

154-0409W-820-33

UTILITY ANALYSIS FOR THE URBAN GROWTH INSIDE THE RECHARGE ZONES OF GROUNDWATER RESOURCES IN SAN ANTONIO AREA

(*b*) OWRT.
(*c*) Dr. C. S. Shih, University of Texas at San Antonio, San Antonio, Tex. 78285.
(*e*) See WRRC **10,** 6.0019.

154-0410W-810-33

WATERSHED IMPACTS OF RECREATIONAL DEVELOPMENT IN THE GUADALUPE MOUNTAINS NATIONAL PARK, TEXAS

(*b*) OWRT.
(*c*) Dr. Ernest Fish, Dr. Marvin Dvoracek, Texas Tech University, Lubbock, Tex. 79409.

154-0411W-860-33

RESERVOIR EUTROPHICATION: FACTORS GOVERNING PRIMARY PRODUCTION

(*b*) OWRT.
(*c*) Dr. Owen Lind, Baylor University, Waco, Tex. 76703.

154-0412W-880-33

STREAM BOTTOM ORGANISMS AS INDICATORS OF ECOLOGICAL CHANGE OF PHASE II

(*b*) OWRT.
(*c*) Dr. Richard Harrel, Lamar University, Beaumont, Tex. 77710.

154-0413W-860-33

EFFECTS OF WATER QUALITY ON RECREATIONAL USE OF WATER IN EAST TEXAS

(*b*) OWRT.
(*c*) Dr. David Gates, Lamar University, Beaumont, Tex. 77710.
(*e*) See WRRC **10,** 5.0429.

154-0414W-800-33

REGIONAL WATER MANAGEMENT WITH FULL CONSUMPTIVE USE

(*b*) OWRT.
(*c*) Dr. Bruce Beattie.

UNIVERSITY OF TEXAS AT AUSTIN, Center for Research in Water Resources, Balcones Research Center, Austin, Tex. 78758. Leo R. Beard, Director.

155-09918-870-33

DESIGN OF URBAN DRAINAGE SYSTEMS FOR DOWNSTREAM FLOOD PLAIN MANAGEMENT

(*b*) Department of the Interior–Office of Water Research and Technology.
(*d*) Theoretical; applied research; for thesis.
(*e*) Investigators developed procedures for the hydrologic design of drainage and storage facilities in urban areas to prevent increased downstream flooding and/or regulate storm runoff for treatment purposes. Such facilities could also provide adequate storm drainage in coordination with flood plain management and insurance measures for areas within and downstream of urban developments.
(*f*) Completed.
(*g*) General guides for design of storage facilities were developed, and a computer model for evaluation of the system operation under various expected storm conditions was formulated and documented. These studies will enable planners to formulate and evaluate a variety of development plans in a reasonable amount of time and at a reasonable cost.

155-09919-350-07

MODEL STUDY OF SPILLWAY OUTLET WORKS FOR RUNNING WATER DRAW SITE NO. 3

(*b*) U.S. Department of Agriculture–Soil Conservation Service.
(*c*) Walter L. Moore, Professor of Civil Engrg., Dept. of Civil Engrg., ECJ 8.6, The Univ. of Texas at Austin, Austin, Tex. 78705.
(*d*) Applied research, design, Masters thesis.
(*e*) Study evaluated the hydraulic performance of spillway outlet works for Running Water Draw Site Number 3, which is proposed for construction in West Texas by the Soil Conservation Service. The proposed facility will serve to help prevent erosion from water flowing through the area. Investigators sought to identify any potential difficulties with the facility and to develop changes that may be necessary to eliminate any problems encountered.
(*f*) Completed.

155-09920-310-33

OPTIMAL FLOOD ROUTING USING STOCHASTIC DYNAMIC PROGRAMMING

(*b*) Department of the Interior–Office of Water Research and Technology.
(*c*) Charles S. Beightler, Professor of Mechanical Engrg., Taylor Hall 147, Univ. Texas at Austin, Austin, Tex. 78705.
(*d*) Theoretical, applied research.
(*e*) Research focuses on the development of flood control policy decisions using an objective function that expresses the economic consequences of flood flows. Flood flows at a particular location were analyzed for conditional probabilities between flows in successive time periods. Using these conditional probabilities, investigators derived optimal flood control policies by use of stochastic dynamic programming. These optimal policies are expressed as matrices which relate operating decisions to future flows and associated probabilities.
(*f*) Completed.
(*g*) The optimal policies developed can be used for real time flood control as well as in planning studies and can also be used for evaluating benefits of flood forecasts. The proposed method is limited to a peak-flow related objective function and therefore allows more rational flood management by use of realistic economic functions where damage is also related to factors such as duration of inundation.

155-09921-800-33

WATER RESOURCE SYSTEM MANAGEMENT FOR INCREASED POWER PRODUCTION

(*b*) Department of the Interior–Office of Water Research and Technology.
(*d*) Theoretical, applied research, Masters thesis, Doctoral dissertation.
(*e*) Develop technology for determining the optimum integration of a large hydroelectric power system into a predominantly thermal power system, thus producing maximum usable energy and peaking capability. Consideration is given to the seasonal variation of trade-offs with other water resource system functions such as flood control, water supply, recreation, and low-flow regulation. The particular objective is to develop, in coordination with the Corps of Engineers, the Southwestern Power Administration, and the Federal Power Commission, specific operation criteria for 13 major reservoirs and 11 hydropower plants in the Arkansas, Red, White, and Osage River Basins that would maximize the generation of power consistent with other system functions and environmental considerations.

155-09922-810-07

WATER YIELD, FLOOD CONTROL AND SEDIMENTATION EFFECTS OF TRINITY RIVER BASIN SCS STRUCTURE

(*b*) U.S. Department of Agriculture–Soil Conservation Service.
(*d*) Applied research, thesis.
(*e*) Investigators are developing procedures for evaluating the various effects of flood water retarding structures at key locations throughout the Trinity River Basin, emphasizing the effects on the operation of Corps of Engineers reservoirs. Specific objectives are to: review literature and past work relative to such determinations; to develop, test, and apply a computer model for evaluating the combined effects of seepage, evaporation, and transpiration at retarding structures on monthly streamflows at any downstream point, including points downstream of Corps of Engineers reservoirs under various modes of operation of those reservoirs; to develop, test, and apply a computer model for evaluating the effects of seepage at retarding structures and in downstream channels on aquifers; to develop, test, and apply a computer model for evaluating the effects of retarding structures on scour and sediment deposition in downstream channels and reservoirs.

155-09923-430-00

THE OFFSET REFLECTING SURFACE CONCEPT, APPLIED TO FLOATING BREAKWATERS AND FLOTATION SYSTEMS FOR WORK BARGES IN THE OCEAN ENVIRONMENT

(*b*) Hydraulic Engineering Program.
(*c*) Walter L. Moore, Dept. Civil Engrg., College of Engrg., Univ. Texas, Austin, Tex. 78705.
(*d*) Experimental, applied research.
(*e*) The offset reflecting surfaces concept is a new principle applied to the design of floating wave protection structures and flotation systems for stable platforms. It provides a basis for a rational design of a floating breakwater to meet known wave conditions and shows promise of being adaptable to a barge flotation system that will restrict barge motion and also provide a sheltered lee for docking of supply vessels. Additional work is to be done on modified configurations both for wave protection and barge flotation. Model studies are underway to evaluate the motion response of a 500 ft by 250 ft work barge with an offset surfaces flotation system. A breakwater installed at Marshal Ford Marina on Lake Travis has been in use for a year and a half and another at a boat launching ramp in Galveston Bay for a year. Improved structural and construction systems are being explored and other installations contemplated. Additional model studies on anchoring forces are underway at the Center for Research in Water Resources.

UNIVERSITY OF TEXAS AT AUSTIN, College of Engineering, Department of Civil Engineering, Austin, Tex. 78712. Dr. Walter L. Moore.

156-02162-810-30

HYDROLOGIC STUDIES, WALLER CREEK WATERSHED

(*b*) Cooperative with U.S. Geological Survey.
(*d*) Field investigation; applied research.
(*e*) Measurements of rainfall and runoff for a 4-square mile and a 2-square mile portion of the Waller Creek watershed are being made to provide basic information for estimating runoff from small urban watersheds in the Southwest area. Two stream flow stations and a rain gage net are in operation. Studies of the correlation between runoff, rainfall, and the characteristics of the drainage basin are being made by various proposed methods to serve as a base comparison with the data as it is collected.
(*g*) Data has been collected since 1956 by the U.S.G.S. and for later years is available in special reports listed below. Data has been used in a number of hydrologic studies and its use will continue.
(*h*) **Compilation of Hydrologic Data, Waller and Wilbarger Creeks, Colorado River Basin, Texas 1966,** Geological Survey, Water Resources Division, Austin, Tex.

156-05456-810-15

MATHEMATICAL MODELS FOR RELATING RUNOFF TO RAINFALL

(*d*) Master's and Doctoral research based on computer analysis and field data.
(*e*) Starting with the Stanford Watershed Model a revised procedure for numerical simulation of watershed hydrology was developed with emphasis on providing a more realistic simulation of infiltration and soil moisture movement. Most recently the simulation program is being used to investigate the effect of lawn watering on runoff on the Waller Creek Watershed in Austin, Texas, where both rainfall and artificial watering support lawn growth. The program is being used to see if the higher level of soil moisture maintained by lawn watering affects the amount of runoff from natural rainfall and thereby compensates to some extent for water used for lawn irrigation. Also some comparisons are made between a few measured soil moisture measurements and simulated values of the soil moisture.
(*g*) Current results show some increase in simulated runoff when lawn irrigation is included, indicating a compensating effect.
(*h*) **Evaluation of Urban Runoff by Watershed Simulation,** W. E. Skipwith, University of Texas at Austin, Austin, Tex., May 1976.

156-08314-430-00

FLOATING BREAKWATER DESIGN

(*c*) Dr. Walter L. Moore.
(*d*) Experimental; applied research; Master's or Doctoral thesis.
(*e*) Active investigation was started in 1970 of a new concept for a floating breakwater. The breakwater minimizes the required anchoring forces and the amplitude of the transmitted wave by causing the wave forces on different parts of the structure to balance one another. Two sets of reflecting surfaces are arranged so the offset between them is approximately one-half the wave length of the largest waves anticipated at the site. Tests in wind generated waves indicated effective wave attenuation for the full range of waves from 1.2 times the design wave down to the smallest wave lengths. A patent on the invention was granted in 1974.
(*h*) **The WAVEGUARD[TM] Offset Surface Floating Barge,** R. J. Taylor, D. B. Jones, *TM M-42-76-16*, Civil Engrg. Lab., Naval Construction Battalion Center, Port Hueneme, Calif. 93043, Sept. 1976.
Corps of Engineers Technical Letter, Engrg. & Design–Floating Breakwater, *Engrg. Tech. Letter 1110-2-202*, Dept. of the Army, Office of the Chief of Engineers, Mar. 1975.
A Stable Offshore Work Barge Using the Offset Reflecting Surfaces Principle, W. L. Moore, J. E. Dailey, J. M. Nash, D. P. Tuterea, *Proc. 3rd Intl. Ocean Development Conf.*, Tokyo, Japan, Aug. 1975.

156-09065-870-00

PREDICTION OF COOLING POND RESPONSE TO WASTEWATER INFLOWS

(*b*) Bureau of Engineering Research.
(*c*) James E. Daily, Asst. Professor of Ocean Engrg., Dept. of Civil Engineering.
(*e*) In water-short areas such as South Texas, an attractive possibility for improving stream quality and/or supplying anticipated cooling water requirements of electric power plants is direct flow of wastewater effluents to cooling ponds. Feasibility of direct inflows depends on algae buildup with subsequent condenser fouling and the quality of water discharged from ponds to natural streams. Objective of the research is to develop a predictive ecological model of cooling pond response to wastewater inflows. Quantitative prediction of algae buildup and discharge water quality by this model will enable accurate assessment of wastewater inflow feasibility.

156-09066-470-60

LOW COST BUOY BARRIERS FOR BOAT RAMP PROTECTION

(*b*) State of Texas, Parks and Wildlife Department.
(*c*) James E. Dailey, Asst. Professor of Ocean Engrg., Dept. of Civil Engineering.
(*e*) At state boat ramp facilities, waves created by passing ships or sudden storms occasionally create uncontrollable situations for boatmen launching or recovering their boats. To reduce the risk of personal injury and property damage, the feasibility of using commercially available plastic shapes to erect a barrier which will dissipate the energy of wave action is being studied. A comparatively low-cost barrier is sought which can be installed easily in the field, using minimum manpower and equipment.

156-09067-410-54

ESTABLISHMENT OF OPERATIONAL GUIDELINES FOR TEXAS COASTAL ZONE MANAGEMENT

(*b*) National Science Foundation, Research Applied to National Needs Program, Office of the Governor, State of Texas, Division of Planning Coordination.
(*c*) James E. Dailey, Asst. Professor of Ocean Engrg., Dept. of Civil Engineering, or E. G. Fruh.
(*g*) See WRRC 9, 6.0941.

UTAH STATE UNIVERSITY, Utah Water Research Laboratory and Utah Center for Water Resources Research, Logan, Utah 84322. Dr. L. Douglas James, Director.

157-0418W-810-00

SORPTIVITY: A FEASIBLE CONCEPT FOR INFILTRATION ESTIMATION ON SMALL RANGE AND WATERSHEDS?

For summary, see Water Resources Research Catalog **11**, 2.0294.

157-0419W-840-00

IMPACT OF WATER AND SOILS WITH HIGH SOURCE-SINK POTENTIALS ON IRRIGATION MANAGEMENT IN THE UPPER COLORADO RIVER BASIN

For summary, see Water Resources Research Catalog **11**, 2.0418.

157-0421W-440-00

A MATHEMATICAL HYDRODYNAMIC CIRCULATION MODEL OF GREAT SALT LAKE FOR RESOURCE MANAGEMENT

For summary, see Water Resources Research Catalog **11**, 4.0041.

157-0422W-820-00

GROUNDWATER MANAGEMENT ALTERNATIVES FOR UTAH

For summary, see Water Resources Research Catalog **11**, 4.0099.

157-0423W-840-00

THE DEVELOPMENT OF PROCEDURES TO IDENTIFY AND PREDICT THE IMPACT OF MANAGEMENT PRACTICES ON THE SALINITY OF AGRICULTURAL RETURN FLOWS

For summary, see Water Resources Research Catalog **11**, 5.1436.

157-0424W-800-00

ALTERNATIVE ENERGY DEVELOPMENT OPTIONS AND THE IMPACT ON WATER RESOURCES AND SALINITY

For summary, see Water Resources Research Catalog **11**, 6.0048.

157-0425W-800-00

WATER RESOURCE MANAGEMENT ALTERNATIVES FOR HYDROPOWER AND GEOTHERMAL DEVELOPMENT

For summary, see Water Resources Research Catalog **11**, 6.0124.

157-0426W-800-00

DEVELOPMENT OF AN INTERACTIVE PLANNING METHODOLOGY FOR DISPLAYING EFFECTS AND ESTABLISHING PUBLIC PREFERENCE AMONG MULTI-OBJECTIVE WATER RESOURCE PLANS

For summary, see Water Resources Research Catalog **11**, 6.0125.

157-0427W-870-00

A STUDY OF THE OVERALL ENERGY EFFICIENCY OF POLLUTION CONTROL TECHNOLOGIES FOR ENERGY CONVERSION PROCESSES

For summary, see Water Resources Research Catalog **11**, 6.0126.

157-0428W-860-00

INNOVATIONS IN DESIGN OF RURAL DOMESTIC WATER SUPPLY SYSTEMS

For summary, see Water Resources Research Catalog **11**, 6.0127.

157-0429W-860-00

THE IMPACT OF ENERGY RESOURCE DEVELOPMENT ON UTAH WATER ALLOCATIONS

For summary, see Water Resources Research Catalog **11**, 6.0179.

157-0430W-870-00

IMPACTS OF WATER QUALITY DISCHARGE PERMIT PROGRAMS ON WATER RIGHTS ADMINISTRATION

For summary, see Water Resources Research Catalog **11**, 6.0219.

157-09076-890-33

FEASIBILITY OF STATE WATER-USE FEES FOR FINANCING WATER DEVELOPMENT AND COST SHARING

(*b*) Office of Water Research and Technology.
(*c*) Dr. Daniel H. Hoggan.
(*d*) Theoretical and field investigation, applied research.
(*e*) As a result of decreasing appropriations of federal funds for water projects in recent years, state and local governments are feeling the pressure to finance a larger share of the costs. One innovative approach to obtaining state funds for water development which appears to have promise is the application of state water-use fees to many or all of the major uses of water. This research project will analyze various use-fee arrangements to determine fund generating potential and feasibility.

157-09078-860-33

OPTIMIZING CROP PRODUCTION THROUGH CONTROL OF WATER AND SALINITY LEVELS IN THE SOIL

(*b*) U.S. Dept. of the Interior, Office of Water Resources and Technology.
(*c*) Dr. J. Paul Riley, Professor (project coordinator).
(*d*) Theoretical and experimental; applied research for M.S. and Ph.D. theses.
(*e*) Field studies are being conducted to examine the response of crops (in terms of dry matter and grain yield) to root stresses applied at different stages of crop growth. Root stresses are induced through both salinity concentrations in the soil moisture solutions and by soil moisture deficiencies. A model will be developed for general application of the results.

157-10142-870-60

LABORATORY INVESTIGATION OF DETRIMENTAL EFFECTS OF ALUMINUM ADDITION TO FRESHWATER LAKES IN NORTHERN UTAH

(*b*) State of Utah.
(*c*) Dennis B. George.
(*d*) Field investigation, data collection.
(*e*) Determine aluminum concentrations in freshwater, which are typical of those found in Utah, which may be detrimental to fish growth and survival.
(*f*) Completed.

157-10143-860-33

NITROGEN CYCLING AS A WATER QUALITY FACTOR IN GREAT SALT LAKE

(*b*) Office of Water Research and Technology, USDI.
(*c*) Frederick J. Post.
(*d*) Field investigation, basic research.
(*e*) Nitrogen is considered to be the limiting factor in the Great Salt Lake. Certain nitrogen processes were studied: namely, nitrification, denitrification, nitrogen fixation, and uptake and mineralization.
(*f*) Completed.
(*g*) The nitrogen cycle was studied using weekly lake samples and sediment-water microcosms. Results from the lake indicated a high level of organic nitrogen as well as undetectable amounts of nitrate, nitrite, and nitrogen fixation. Ammonia was the only detectable inorganic nitrogen form and occurred in the lake only at times of low algal activity or high excretion rates by the invertebrates or high bacterial activity. Microcosm studies demonstrated that ammonia, nitrate, and urea did not stimulate the bacteria directly but did so only indirectly through increased algal activity. Glutamic acid, an organic form of nitrogen, stimulated the bacteria directly. No nitrification was observed in the microcosms although nitrite was observed when the microcosms were fed nitrate (denitrification).
(*h*) **Nitrogen Cycling in Microcosms and Application to the Biology of the Northern Arm of the Great Salt Lake,** *PRJ-SBA-016-1*, Utah Water Research Lab., Utah State Univ., Logan, Utah 84322.

157-10144-860-33

DEVELOPMENT OF A HYDROQUALITY MANAGEMENT MODEL OF GREAT SALT LAKE

(*b*) Office of Water Research and Technology.
(*c*) J. Paul Riley.
(*d*) Theoretical, development.
(*e*) To formulate a hierarchical-multilevel management model.
(*f*) Completed.
(*g*) The development of a model capable of predicting the long term (seasonal) distribution of water quality constituents within Great Salt Lake was undertaken as a portion of the ongoing Great Salt Lake project at USU. This study provides a model capable of monitoring the long term distribution of quality constituents within the lake. This capability is a necessary component of the modeling framework since it will allow the investigation of the effects which alternative water quality management plans will have on the distribution of water quality constituents within the lake.
(*h*) **Development of a Water Quality Simulation Model Applicable to Great Salt Lake, Utah,** *PRJEW-026-1*, Utah Water Research Lab., Utah State Univ., Logan, Utah 84322.

157-10145-800-33

IMPACTS ON AGRICULTURAL LAND USE, INCOME AND EMPLOYMENT RESULTING FROM WATER TRANSFERS TO FACILITATE OIL SHALE DEVELOPMENT

(*b*) Office of Water Research and Technology.
(*c*) B. Delworth Gardner.
(*d*) Theoretical, development.
(*e*) Review and evaluate the hypothesized water needs of an oil shale industry of various sizes and will investigate the alternative options of meeting these requirements. Impacts on agricultural land use, income and employment will be analyzed as the primary thrust of the study. Programs and policies to facilitate resource adjustments will receive attention, with focus upon alternative arrangements for transferring water.
(*f*) Completed.
(*g*) Historical development of the appropriation doctrine of water allocation was outlined and Utah water policy was examined. These factors are analyzed in light of the prototype oil shale development in the Uintah Basin and potential impact on the area's agricultural sector. Oil shale water estimates are compared with Uintah Basin water availability and examined with regard to population projections and municipal water use.
(*h*) **The Effects of Agriculture in Utah of Water Transfers to Oil Shale Development,** *PRJAE-027-1*, Utah Water Research Lab., Utah State Univ., Logan, Utah 84322.

157-10146-800-33

WATER AS A FACTOR IN ENERGY RESOURCE DEVELOPMENT

(*b*) Office of Water Research and Technology.
(*c*) A. Bruce Bishop.
(*d*) Theoretical, development.
(*e*) Determine the amount of water available in Utah for development of coal and oil shale and the amount of water used for strip mining and energy conversion processes which are proposed for the region. Also, the trade-offs will be examined for locating the energy activities on alternative sites.
(*f*) Completed.
(*g*) For the initial application of the model, optimal solutions were obtained for both energy maximization and water minimization which illustrate composite system effects and potential conflicts that could arise from various combinations of water allocation to energy resources developments.
(*h*) **Water as a Factor in Energy Resources Development,** *PRJER-028-1*, Utah Water Research Lab., Utah State Univ., Logan, Utah 84322.

157-10147-440-33

A STUDY OF TRANSPORT PROCESSES OF THE GREAT SALT LAKE

(*b*) Office of Water Research and Technology and the State of Utah.
(*c*) Anching Lin.
(*d*) Field investigation, basic research.
(*e*) Establish, through the understanding of the transport processes of the water in the lake, inter-relationship between the various elements of resources development in the lake and thus provide scientific bases for sound policy-making in the planning and management of the lake.
(*f*) Completed.
(*g*) Of some interest to limnologists is the meromixis (sustained two-layer stratification) in the south basin. The conspicuous two-layer lake was made possible by the presence of the railroad causeway. It is found that the rate of entrainment of the chemocline obeys the general rules applicable to other large two-layer basins.
(*h*) **A Survey of the Physical Limnology of Great Salt Lake,** *Utah Div. of Water Resources–Comprehensive Water Planning Program*, 435 State Capitol Bldg., Salt Lake City, Utah 84114.

157-10148-870-33

INTERMITTENT SAND FILTER SCRAPINGS–DEPOSITION, UTILIZATION, AND SAND RECOVERY

(*b*) Office of Water Research and Technology.
(*c*) James H. Reynolds.
(*d*) Experimental, applied research.
(*e*) Intermittent sand filtration of wastewater stabilization pond effluent is an extremely effective means of removing algae from wastewater. However, an algae laden crust frequently forms on the filter surface, and the filter must be scraped to be fully rejuvenated. Scraping is a time and money consuming process especially if fresh sand must be applied to municipal scale filters. This research tested and evaluated methods by which sand scrapings could be utilized.
(*f*) Completed.
(*g*) Results indicated that three disposal alternative methods were viable recourses for sewage sand filter, sand deposition, and utilization. Cost analyses indicated that an irrigation technique may be less expensive.
(*h*) **Disposal Alternatives for Intermittent Sand Filter Scrapings Utilization and Sand Recovery,** *PRJER-033-1*, Utah Water Research Lab., Utah State Univ., Logan, Utah 84322.

157-10149-870-73

USE OF WARM AND/OR SALINE EFFLUENT WATERS FROM ELECTRICAL GENERATING POWER PLANTS FOR FOOD PRODUCTION

(*b*) Utah Power & Light Company.
(*c*) Jay M. Bagley.
(*d*) Field investigation, operation.
(*e*) Explore management techniques for solving some of the problems of power generation and food production simultaneously or in combination.

157-10150-810-60

WATER QUALITY MANAGEMENT ON MOUNTAIN WATERSHEDS

(*b*) State of Utah.
(*c*) E. Joe Middlebrooks.
(*d*) Field investigation, development.
(*e*) Describe and define the impact of recreational development on mountain watersheds in a quantitative sense.

157-10151-210-70

TESTING A MCNALLY 24" BUTTERFLY VALVE

(*b*) McNally Pittsburg Mfg. Corporation.
(*c*) Calvin G. Clyde.
(*d*) Experiment, operation.

(e) Test of a large butterfly valve will verify its performance prior to its acceptance by the buyer.

157-10152-890-06

STUDIES TO INVESTIGATE PROPERTIES OF MATERIAL IN PHOSPHATE MINES IN RELATIONSHIP TO OPTIMUM DESIGN OF SPOIL DUMPS

(b) U.S. Forest Service.
(c) Roland W. Jeppson.
(d) Experimental, design.
(e) Engineering and nutrient properties will be determined from each separately identifiable geologic formation constituting the overburden material of the phosphate mines in Southeast Idaho by laboratory tests.

157-10153-480-60

EXPERIMENTAL INVESTIGATION OF CLOUD SEEDING POTENTIAL IN WINTER OROGRAPHIC STORMS

(b) State of Utah.
(c) Geoffrey E. Hill.
(d) Field investigation, operation.
(e) Cloud seeding material is injected into winter clouds by aircraft upwind of a target area, wherein an instrumented aircraft detects resulting changes.

157-10154-480-60

CLIMATOLOGY OF HAILSTORMS IN UTAH–THE HAIL SUPPRESSION POTENTIAL BY CLOUD SEEDING

(b) State of Utah/Division of Water Resources.
(c) Kenneth G. Hubbard.
(d) Experimental, development.
(e) Identify and analyze the climatology of Utah hailstorms as a means of determining the potential for hail suppression through the use of cloud seeding.

157-10155-480-06

COOPERATIVE DATA SYSTEM

(b) USDA/Wasatch National Forest Service.
(c) Duane G. Chadwick.
(d) Field investigation, data collection.
(e) Gather data on wind energy and related parameters.

157-10156-860-60

EVALUATION OF CONSTRAINING ELEMENTS IN MAKING WATER USE CHANGES

(b) State of Utah/Division of Water Rights.
(c) Jay M. Bagley.
(d) Theoretical, development.
(e) A guide, based on a systematic consideration of the factors involved in any change from one water use to another, will be developed for administrators who make decisions about water change use applications.

157-10157-870-36

SEPARATION OF ALGAE CELLS FROM WASTEWATER LAGOON EFFLUENTS

(b) Environmental Protection Agency.
(c) E. J. Middlebrooks.
(d) Experimental, development.
(e) Develop a practical, reliable, cost-effective method for the removal and disposal of algae cells from waste stabilization lagoon effluents.

157-10158-860-60

THE BIOLOGICAL ROLE OF SPECIFIC ORGANIC COMPOUNDS IN AQUATIC ECOSYSTEMS PRODUCED BY OIL SHALE DEVELOPMENT

(b) State of Utah.
(c) V. Dean Adams.
(d) Experimental, operation.
(e) Evaluate the biological role of specific organic compounds and the effects of salinity on the stream biota in the Colorado River Basin.

157-10159-860-60

HYDROLOGIC AND WATER QUALITY IMPACTS OF CONSERVATION MEASURES ON UTAH RIVER BASINS

(b) State of Utah.
(c) Eugene K. Israelsen.
(d) Experimental, operation.
(e) Estimate the distribution of water quantity and quality in time and space resulting from implemented conservation measures in Utah river basins.

157-10160-820-60

GROUNDWATER MANAGEMENT ALTERNATIVES FOR UTAH: AN ECONOMIC ANALYSIS

(b) State of Utah.
(c) John E. Keith.
(d) Theoretical, development.
(e) Economic analysis of the current groundwater use restriction and of various legal-institutional controls.

157-10161-870-60

MANAGEMENT ALTERNATIVES FOR LIVESTOCK WASTE RUNOFF CONTROL IN UTAH

(b) State of Utah.
(c) James H. Reynolds.
(d) Experimental, operation.
(e) Identify and quantify the impact of animal feedlot runoff on the water quality of Cache Valley, specifically; and of the State of Utah in general.

157-10162-870-60

RESIDUAL HEAVY METAL REMOVAL BY A WASTEWATER GROWN ALGAE-INTERMITTENT SAND FILTRATION SYSTEM

(b) State of Utah.
(c) Daniel S. Filip.
(d) Field investigation, operation.
(e) Feasibility of using phytoplanktonic algae to incorporate heavy metals from wastewater for subsequent removal by intermittent sand filtration.

157-10163-480-54

FACTORS CONTROLLING THE SIZE, SPACING, AND LIFETIME OF CUMULUS CLOUDS AS REVEALED BY NUMERICAL EXPERIMENTS

(b) National Science Foundation.
(c) Geoffrey E. Hill.
(d) Field investigation, development.
(e) Develop an increased understanding of convective-cloud behavior, thereby aiding in the prediction of precipitation and ultimately in the prediction of severe storms.

157-10164-480-60

EXPERIMENTAL WEATHER MODIFICATION

(b) State of Utah/Division of Water Resources.
(c) Geoffrey E. Hill.
(d) Field investigation, development.
(e) What meteorological conditions are most suitable for increasing precipitation by cloud seeding. Precipitation amounts received during seeded storms are compared (by use of a numerical prediction model) with amounts expected if seeding were not done.

157-10165-860-60

DEVELOPMENT OF A CONSUMPTIVE WATER USE MAP FOR UTAH

(b) State of Utah/Division of Water Rights.
(c) Jay M. Bagley.
(d) Experimental, design.

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(*e*) Develop a better understanding of consumptive water use and will prepare maps which present the information in an easily usable form.

157-10166-870-33

OVERLAND FLOW AND SPRAY IRRIGATION TO UPGRADE WASTEWATER LAGOON EFFLUENT

(*b*) Office of Water Research and Technology.
(*c*) Daniel S. Filip.
(*d*) Field investigation, operation.
(*e*) Compare and evaluate overland flow and spray irrigation as final upgrading processes for municipal wastewater lagoon effluent.

157-10167-810-33

HYDROLOGIC IMPACT OF GRAZING SYSTEMS ON INFILTRATION AND RUNOFF: DEVELOPMENT OF A MODEL

(*b*) Office of Water Research and Technology.
(*c*) Gerald F. Gifford.
(*d*) Field investigation, operation. .
(*e*) Synthesizing from literature all available information regarding impacts of grazing on infiltration and runoff.

157-10168-630-33

A COST-EFFECTIVE SOLAR-POWERED WATER PUMP

(*b*) Office of Water Research and Technology.
(*c*) Duane G. Chadwick.
(*d*) Experimental, operation.
(*e*) Perfect a prototype solar-powered water pump now in existence which will be cost effective for use on small farms having a nearby groundwater or surface water supply that requires moderate lifting.

157-10169-840-33

POTENTIAL FOR USING WASTE WATER FROM ELECTRICAL POWER PLANTS FOR IRRIGATION

(*b*) Office of Water Research and Technology.
(*c*) R. John Hanks.
(*d*) Field investigation, operation.
(*e*) Possibility of using wastewater from electrical power plants in a productive way–as an irrigation water supply.

157-10170-860-33

A CHEMICAL MODEL OF HEAVY METALS IN THE GREAT SALT LAKE

(*b*) Office of Water Research and Technology.
(*c*) J. J. Jurinak.
(*d*) Basic research, theoretical.
(*e*) Formulation and validation of a thermodynamic model to define the natural physico-chemical processes that control the solubility of heavy metals in Great Salt Lake brine.

157-10171-860-33

ESTIMATING THE UNCERTAINTY ASSOCIATED WITH PREDICTED SALINITY LEVELS IN THE UPPER COLORADO RIVER BASIN

(*b*) Office of Water Research and Technology.
(*c*) William J. Grenney.
(*d*) Basic research, theoretical.
(*e*) Estimate the statistical uncertainty associated with predicting future salinity levels in the Upper Colorado River Basin.

157-10172-870-33

INVESTIGATIONS OF VIRUS REMOVAL FROM WATER WITH AN EVALUATION OF A NEW VIRUS DETECTION PROCEDURE

(*b*) Office of Water Research and Technology.
(*c*) Rex S. Spendlove.
(*d*) Experimental, development.
(*e*) Evaluate virus removal and inactivation capability of sand filters used in water treatment. Determine the chlorination inactivation rates of two model viruses in water of selected quality. Determine *in situ* kinetics for virus inactivation in sewage lagoons and fresh water sources. Evaluate the fluorescent virus precipitin test for use in routine screening of water and wastewater for enteric viruses. Determine the potential use of reovirus as a standard in water studies.

157-10173-860-33

VULNERABILITY OF WATER SUPPLY SYSTEMS TO DROUGHTS

(*b*) Office of Water Research and Technology.
(*c*) David S. Bowles.
(*d*) Experimental, development.
(*e*) A drought severity index will be developed to describe the state of a drought as it affects beneficial uses of water. This index will be useful as a basis for 1) assessing the relative vulnerability to drought of water supply systems; 2) prioritizing the use of funds for reducing drought vulnerability of different water management alternatives; and 3) allocating water to drought susceptible communities and other water users.

157-10174-860-33

SALINITY MANAGEMENT OPTIONS FOR THE COLORADO RIVER

(*b*) Office of Water Research and Technology (regional project–Colorado State University, BLM, University of California-Riverside, University of Arizona).
(*c*) Jay C. Andersen.
(*d*) Experimental, design.
(*e*) Designed to aid local, state and federal agencies in ameliorating the salinity problem of the Colorado River.

157-10175-800-33

OPTIMIZATION OF WATER RESOURCES SYSTEMS USING INTERACTIVE INTEGER PROGRAMMING-SIMULATION MODELS

(*b*) Office of Water Research and Technology.
(*c*) William J. Grenney.
(*d*) Theoretical, design.
(*e*) Develop and apply integer optimization and simulation modeling to two important dimensions of water resources management problems.

157-10176-800-33

STOCHASTIC MODELING OF WATER SURFACE ELEVATIONS FOR TERMINAL LAKES

(*b*) Office of Water Research and Technology/State of Utah.
(*c*) L. Douglas James.
(*d*) Experimental, design.
(*e*) A technique for establishing the frequency distribution of terminal lake stages at different time horizons will be developed.

157-10177-860-33

IDENTIFICATION OF PRESUMPTIVE CARCINOGENIC COMPOUNDS RELEASED TO WATER SUPPLIES BY OIL SHALE

(*b*) Office of Water Research and Technology/State of Utah.
(*c*) V. Dean Adams.
(*d*) Field investigation, operation.
(*e*) Determine the potential mutagenic and carcinogenic hazards posed by the development of oil shale in Utah, Wyoming, and Colorado.

VANDERBILT UNIVERSITY, Environmental and Water Resources Engineering, Nashville, Tenn. 37235. Dr. R. H.

French, Asst. Professor, Hydraulic and Water Resources Engineering.

158-09900-060-33

INTERFACIAL STABILITY OF A TWO LAYER FLOW WITHOUT SHEAR IN THE PRESENCE OF BOUNDARY GENERATED TURBULENCE: FIELD VERIFICATION

(*b*) U.S. Department of Interior, University of Tennessee Water Resources Center.
(*d*) Field Investigation; applied research; Master's thesis.
(*e*) Field verification of a model to determine whether superposed layers of fluid are stable or unstable; i.e., is there substantial mixing across the interface or not.
(*h*) **Interfacial Instability in Stratified Flow,** R. H. French, *15th Intl. Coastal Engrg. Conf.*, Honolulu, Hawaii, July 1976.
Interfacial Stability of a Two Layer Flow Without Shear in the Presence of Boundary Generated Turbulence: Field Verification, S. McCutcheon, *M.S. Thesis*, Vanderbilt University, 1977.
Interfacial Instability in Stratified Flow, S. McCucheon, R. French, *ASCE Hydraulics Div. Specialty Conf.*, College Station, Tex., Aug. 1977.

158-09901-200-00

THE EFFECT OF STABLE DENSITY STRATIFICATION IN OPEN CHANNEL FLOW ON THE VERTICAL VELOCITY PROFILE AND THE CHÉZY ROUGHNESS COEFFICIENT

(*d*) Theoretical; basic research.
(*e*) A theoretical investigation of how density stratification effects the shape of the vertical velocity profile in open channel flow and hence the Chézy roughness coefficient.
(*h*) **Stratification and the Chézy Coefficient,** R. H. French, *ASCE Hydraulics Div. Specialty Conference*, College Station, Tex., Aug. 1977.

VIRGINIA INSTITUTE OF MARINE SCIENCE, COMMONWEALTH OF VIRGINIA, Department of Estuarine Processes and Chemical Oceanography, Gloucester Point, Va. 23062. Dr. B. J. Neilson, Department Head.

159-09889-390-41

ENGINEERING DESIGN OF OYSTER DEPURATION PLANTS

(*b*) U.S. Food and Drug Administration.
(*d*) Design, applied research.
(*e*) Develop guidelines for the design and operation of an oyster depuration plant. Of special importance were the design characteristics of the tank in which the oysters are held during the several day depuration period. Full scale experiments were made varying water flow, quantity of oyster per tank and the hydraulic characteristics of the tanks. Final recommendations are based on analysis of the findings of these studies plus review of procedures at existing shellfish depuration plants in New England.
(*f*) Completed.
(*h*) **A Mathematical Approach to Depuration,** B. J. Neilson, *1975 Proc. Natl. Shellfisheries Association.*
Practical Considerations for the Bacterial Depuration of Oysters in the Chesapeake Bay Region, B. J. Neilson, D. S. Haven, F. O. Perkins, *Contract Report to Food and Drug Administration*, Jan. 1977.

159-09890-870-36

STORMWATER SAMPLING

(*b*) U.S. Environmental Protection Agency, Hampton Roads Water Quality Agency.
(*d*) Field investigation, applied research.
(*e*) Twenty-five sites within the Peninsula and Southeastern Virginia Planning Districts were sampled twice each to determine the runoff quantity and quality. These sites included a broad range of soil types, topographies, and land uses. In general, each site was sampled once in the spring and once in the fall of 1976, with a light rainfall on one occasion and a heavy rainfall on the other sampling. Water quality measures which were monitored are: fecal coliforms, nutrients, 30-day Biochemical Oxygen Demand and suspended solids. The data generated by this field sampling program will be used to calibrate stormwater models of the river basins in the Hampton Roads area, in order to predict future non-point source pollution loads.
(*f*) Completed.
(*g*) Runoff characteristics for the Coastal Plains are different from those for other geological provinces. Sandy, highly permeable soils and very gentle stream gradients result in lower runoff rates and, therefore, less pollutant transfer.
(*h*) **Stormwater Sampling in the Hampton Roads Area,** B. J. Neilson, *Contract Report to Hampton Roads Water Quality Agency*, Feb. 1977.

159-09891-400-36

WATER QUALITY AND MODELING STUDIES OF THE SMALL COASTAL BASINS

(*b*) U.S. Environmental Protection Agency, Hampton Roads Water Quality Agency.
(*d*) Field investigation, applied research.
(*e*) Intensive field surveys and slack water monitoring surveys were made of four small coastal basins on the Chesapeake Bay: Back River, Poquoson River, Little Creek Harbor, and the Lynnhaven Bay System. The data from these surveys have been used to evaluate present water quality conditions and to calibrate mathematical models. The Back and Poquoson rivers are being simulated by one-dimensional, time varying models developed under the Cooperative State Agencies program by VIMS. For Little Creek and Lynnhaven, Ketchum's tidal prism model has been modified to suit local conditions. Water quality measures that have been modeled are: dissolved oxygen, Biochemical Oxygen Demand, chlorophyll "a", nutrients, and fecal coliforms. These models will be used to assess the relative impacts of point and non-point sources of pollution. Waste load allocation schemes will be developed to assure satisfactory water quality conditions in the future.
(*h*) **A Model of Tidal Flushing for Small Coastal Basins,** A. Y. Kuo, *Proc. Conf. Environmental Modeling and Simulation*, Cincinnati, Ohio, U.S. EPA, Apr. 1976.
Water Quality in the Small Coastal Basins, B. Neilson, *Report to Hampton Roads Water Quality Agency*, Aug. 1976.

159-09892-400-36

WATER QUALITY AND MODELING STUDIES OF THE LOWER JAMES AND YORK ESTUARIES

(*b*) U.S. Environmental Protection Agency, Hampton Roads Water Quality Agency.
(*d*) Field investigation, applied research.
(*e*) Intensive field surveys and slack water monitoring surveys were made of several tributaries of Chesapeake Bay: the York River and the James River including the Elizabeth River, Nansemond River and Pagan River. Data from these surveys will be used to evaluate present water quality conditions and to calibrate mathematical models. All models are time-varying and include the following water quality measures: fecal coliforms, dissolved oxygen, Biochemical Oxygen Demand, chlorophyll "a", and nutrients. These models will be used to assess the relative impacts of point and non-point sources of pollution. Where necessary, waste load allocation schemes will be developed to bring ambient water quality up to the appropriate stream standards.

VIRGINIA INSTITUTE OF MARINE SCIENCE, COMMONWEALTH OF VIRGINIA, Department of Physical Oceanog-

raphy and Hydraulics, Gloucester Point, Va. 23062. Dr. C. S. Fang, Department Head.

161-08332-870-52

FATE OF WASTE HEAT DISCHARGED INTO THE JAMES RIVER ESTUARY BY THE SURRY NUCLEAR POWER STATION AT HOG POINT, SURRY COUNTY, VIRGINIA

(*b*) Energy Research and Development Administration.
(*d*) Field investigation; applied research.
(*e*) Temperature profiles in the vicinity of the mixing zone of the heated water discharge plume were determined. Deduced thermal patterns were compared with those obtained from previous model studies under similar wind and flow conditions to evaluate the relevance of model studies for these purposes. The importance of winds on the movement of the thermal effluent were under particular consideration.
(*g*) Data collected indicated that there were any extreme temperatures outside the near field region of the outfall that would cause biological damage. Continued monitoring of the area was necessary to identify yearly variation of parameters and to monitor under higher plant output conditions. Data 1973 indicated that the thermal plume is not as extensive as predicted by the James River Hydraulic Model. The model is best suited for far field analysis of the thermal plume.
(*h*) **The Design of the Monitoring System for the Thermal Effects Study of the Surry Nuclear Power Plant on the James River,** R. L. Bolus, S. N. Chia, C. S. Fang, *VIMS SRAMSOE* **16,** Oct. 1971.
Thermal Effects of the Surry Nuclear Power Plant on the James River, Virginia, Part II. Results of Monitoring Physical Parameters of the Environment Prior to Plant Operation, S. N. Chia, C. S. Fang, R. L. Bolus, W. J. Hargis, Jr., *VIMS SRAMSOE* **21,** Feb. 1972.
Thermal Effects of the Surry Nuclear Power Plant on the James River, Virginia, Part III. Results of Monitoring Physical Parameters of the Environment Prior to Plant Operation, E. A. Shearls, S. N. Chia, W. J. Hargis, Jr., C. S. Fang, R. N. Lobecker, *VIMS SRAMSOE* **33,** Feb. 1973.
Thermal Effects of the Surry Nuclear Power Plant on the James River, Virginia, Part IV. Results of Monitoring Physical Parameters During the First Year of Plant Operation, *VIMS SRAMSOE* **51,** Feb. 1974.
An Estuarine Thermal Monitoring Program, C. S. Fang, G. C. Parker, E. A. Shearls, W. J. Hargis, *Thermal Pollution Analysis Conf.*, VPI and SU, Blacksburg, Va., May 1974.
Hydrothermal Monitoring: Surry Nuclear Power Plant, C. S. Fang, G. Parker, W. Harrison, *14th Intl. Conf. Coastal Engrg.*, Copenhagen, Denmark, June 1974.
The Design of a Thermal Monitoring System, R. L. Bolus, C. S. Fang, S. N. Chia, *Marine Tech. Soc. J.* **7,** 7, 1973.
Thermal Effects of the Surry Nuclear Power Plant on the James River, Virginia, Part V. Results of Monitoring Physical Parameters During the First Two Years of Plant Operation, G. C. Parker, C. S. Fang, *VIMS SRAMSOE* **92,** 1975.
Thermal Effects of the Surry Nuclear Power Plant on the James River, Virginia, Part VI. Results of Monitoring Physical Parameters of the Surry Nuclear Power Plant, C. S. Fang, G. C. Parker, *VIMS SRAMSOE* **109,** Feb. 1976.
Thermal Discharges; Prototype Versus Hydraulic Model, G. C. Parker, C. S. Fang, A. Y. Kuo, *15th Conf. Intl. Coastal Engrg.*, May 1976.

161-09151-450-00

A TWO-DIMENSIONAL TIME-DEPENDENT NUMERICAL MODEL INVESTIGATION OF THE COASTAL SEA CIRCULATION AROUND THE CHESAPEAKE BAY ENTRANCE

(*c*) A. Y. Kuo, Assoc. Marine Scientist.
(*d*) Ph.D. dissertation.
(*e*) A numerical study was made of the flow field arising from the discharge of a tidal estuary onto the continental shelf. The approach was to: 1) vertically integrate the continuity, momentum, and mass balance equations assuming incompressible flow and using hydrostatic assumption and Boussinesq approximation; 2) numericably integrate the vertically integrated equations; 3) apply the equations to a simplified coastal geometry and determine the effect of different physical factors on the flow field.
(*f*) Completed.
(*g*) The conclusions from the study show that the outflow from an estuary can be divided into three types; dispersive, entraining, and a mixture of the two. The study also shows the existence of a northern flow above the Chesapeake Bay entrance and a weak residual eddy motion above and below the Bay mouth.
(*h*) **A Two-Dimensional Time-Dependent Numerical Model Investigation of the Coastal Sea Circulation Around the Chesapeake Bay Entrance,** E. M. Stanley, *Ph.D. Dissertation*, College of William and Mary, 1976.

161-09152-450-50

WIND GENERATED INERTIAL CURRENTS

(*b*) National Aeronautics and Space Administration, Wallops Island Station; Virginia Institute of Marine Science.
(*c*) C. S. Welch, Assoc. Marine Scientist.
(*d*) Thesis research, W. Saunders (College of William and Mary).
(*e*) A study of the effects of wind generation on inertial currents in the Atlantic Ocean. Data from current meters and anemometers are being used in addition to a mathematical model used to predict inertial currents. This model includes the effects of wind field over the array.

161-09163-860-88

THE CHESAPEAKE BAY: A STUDY OF PRESENT AND FUTURE WATER QUALITY AND ITS ECOLOGICAL EFFECTS

(*b*) National Commission on Water Quality.
(*c*) A. Y. Kuo, Assoc. Marine Scientist, Vol. 1, Morris H. Roberts, Jr., Assoc. Marine Scientist, Vol. 2.
(*d*) Applied research.
(*e*) Prepare descriptions of present Chesapeake Bay water quantity and quality, projections of future water quality and assessing the biological, ecological and environmental impacts.
(*f*) Completed.
(*g*) The result of this project was two volumes describing the analysis of present water quality and quantity and ecological conditions in the area and projections for the future water quality and ecological effects.
(*h*) **The Chesapeake Bay: A Study of Present and Future Water Quality and Its Ecological Effects. Vol. 1: Analysis and Projection of Water Quality,** A. Y. Kuo, A. Rosenbaum, J. P. Jacobson, C. S. Fang.
Vol. 2: Analysis and Projection of Ecological Conditions, M. H. Roberts, Jr., D. F. Boesch, M. E. Bender.
Submitted to National Commission on Water Quality, June 1975.

161-09165-400-60

COOPERATIVE STATE AGENCIES (CSA) ESTUARINE WATER QUALITY MODELING PROGRAM

(*b*) Virginia State Water Control Board, Richmond, Virginia.
(*c*) A. Y. Kuo, Assoc. Marine Scientist.
(*d*) Experimental, including field investigation and numerical modeling; applied research.
(*e*) A sequence of water quality models is being developed for Virginia estuaries for use by planning agencies as a management aid. The James, York, Rappahannock, and several smaller estuaries are included. The project commenced with one-dimensional salinity intrusion and dissolved oxygen models of the major estuaries but has expanded to encompass dynamic modeling, modeling of nitrogenous BOD and two-dimensional and two-layer modeling. Also planned are ecosystem models including the nutrient cycle and the growth of phytoplankton.

(*g*) Field studies indicate that low oxygen conditions and high algal populations occur on a localized and seasonal basis, indicating the need for modeling to assess the impact of development on critical conditions. Estuarine stratification and water quality are clearly influenced by the annual hydrologic cycle.
(*h*) **Hydrography and Hydrodynamics of Virginia Estuaries, Part IV. Mathmatical Model Studies of Water Quality in the James Estuary,** C. S. Fang, et al., *Spec. Rept. No. 41*, Va. Inst. of Marine Science, Sept. 1973.
Mathematical Modeling of Virginia Estuaries for Management, C. S. Fang, A. Y. Kuo, P. V. Hyer, presented Virginia Academy of Science, Norfolk, Va., May 1974.
Hydrography and Hydrodynamics of Virginia Estuaries. VI. Mathematical Model Studies of Water Quality of the Rappahannock Estuary, A. Y. Kuo, A. Rosenbaum, P. V. Hyer, C. S. Fang, W. J. Hargis, Jr., *VIMS Sramsoe* **102,** 1975.
Hydrography and Hydrodynamics of Virginia Estuaries. VIII. Mathematical Model Studies of Water Quality of the York River System, P. V. Hyer, A. Y. Kuo, C. S. Fang, W. J. Hargis, Jr., *VIMS Sramsoe* **104,** 1975.
Hydrography and Hydrodynamics of Virginia Estuaries. VII. Mathematical Model Studies of Water Quality of the Pagan Estuary, A. Y. Kuo, J. K. Lewis, C. S. Fang, *VIMS Sramsoe* **107,** Jan. 1976.
A Model of Tidal Flushing for a Small Coastal Basin. Environmental Modeling and Simulation, A. Y. Kuo, *U.S. Environmental Protection Agency, EPA 600/9-76-061.*

161-09874-400-60

A TWO-DIMENSIONAL ECOSYSTEM MODEL FOR THE LOWER JAMES RIVER

(*b*) Hampton Roads Water Quality Agency, Virginia State Water Control Board.
(*c*) A. Y. Kuo, Assoc. Marine Scientist.
(*e*) A two-dimensional (in horizontal plane) model is being developed for the James Estuary from the confluence of the Chickahominy to its mouth. The model includes two sub-models: the hydrodynamic sub-model simulates the interaction of tidal wave and freshwater runoff; the water quality model simulates the distribution of salinity, dissolved oxygen, various forms of nutrients and phytoplankton. After calibration and verification, the model will be used to study the circulation and the transport of pollutants in the Lower James Estuary and Hampton Roads.
(*h*) *Ph.D. Dissertation*, G. M. Sisson, College of William and Mary.

161-09875-720-50

EOLE BUOY DATA PROCESSING AND INTERPRETATION

(*b*) National Aeronautics and Space Administration (Langley Research Center).
(*c*) E. P. Ruzecki, Assoc. Marine Scientist.
(*d*) Experimental, field investigation, applied research.
(*e*) Examine data from drifting buoys which were released near Chesapeake Light and other locations on the Virginia continental shelf and tracked by the French EOLE satellite. The relations between the buoy tracker, weather conditions, and hydrographic structure are being examined.
(*h*) **The Use of the EOLE Satellite Systems to Observe Continental Shelf Circulation,** E. P. Ruzecki, et. al, *Offshore Tech. Conf.*, May 1977.
Virginia Institute of Marine Science (VIMS)-NASA Langley Research Center (LaRC) EOLE BUOY Program, C. S. Welch, *AIAA Tech. Comm. Marine Systems and Technologies Symp. Free Drifting Buoys*, 1974.

161-09876-450-00

ON THE IMPORTANCE OF NORFOLK CANYON AND CONTINENTAL SHELF WATER CIRCULATIONS

(*c*) E. P. Ruzecki, Assoc. Marine Scientist.
(*e*) This study is intended to determine the importance of submarine canyons as an avenue of exchange for waters between the continental shelf and continental slope areas.
(*h*) *Ph.D. Dissertation*, Evon P. Ruzecki, University of Virginia.

161-09877-450-34

OUTER CONTINENTAL SHELF BENCHMARK STUDIES–PHYSICAL OCEANOGRAPHY

(*b*) U.S. Department of Interior (Bureau of Land Management).
(*c*) E. P. Ruzecki, Assoc. Marine Scientist.
(*d*) Field investigation, applied research.
(*e*) Measurements of temperature, salinity, dissolved oxygen, and micronutrients (nitrites, nitrates, and phosphates) at approximately 50 stations will be used to identify water masses in the study area. Data will be presented as cross-shelf sections of temperature, salinity, dissolved oxygen and density (sigma-t) and also as T-S plots for each station or group of stations.

161-09878-870-68

FINE SCALE CIRCULATION NEAR "FOXTROT" IN HAMPTON ROADS, VIRGINIA

(*b*) Hampton Roads Sanitation District Commission; National Aeronautics and Space Administration.
(*c*) C. S. Welch, Assoc. Marine Scientist.
(*d*) Field investigation, applied research, design.
(*e*) A definitive surface circulation study was performed to examine tidal circulation from a definite proposed outfall site for a sewage treatment plant. The study was performed using the remote sensing–dye buoy technique and recommendations were made based on the results to the Hampton Roads Sanitation District Commission.
(*f*) Completed, January 1976.
(*h*) **Fine Scale Circulation Near "Foxtrot" in Hampton Roads, Virginia,** C. S. Welch, B. J. Neilson, *Addendum to Oceanographic Water Quality and Modeling Studies for the Outfall from a Proposed Nansemond Waste Water Treatment Plant*, report submitted to McGaughy, Marshall & MacMillan–Hazen & Sawyer: A Joint Venture, 1976.

161-09879-720-00

OMEGA BUOY PROJECT

(*c*) Chris Welch, Assoc. Marine Scientist.
(*d*) Experimental, design, development.
(*e*) A remote navigation system utilizing the Omega Navigation net is being developed at VIMS. This system is suitable for the automatic and continuous tracking of at least five drogued buoys in the major estuaries of Virginia, the Chesapeake Bay, and the continental shelf waters. It features automatic operation, unattended during weekends and holidays, low operating cost, continuous availability, and moderate accuracy. A prototype field test has been run of the entire system loop for the navigation system.
(*h*) **A Prototype Langrangian Current Buoy Using the Carrier Plus Sideband CSB Retransmission of Omega Navigation Signals,** D. Baker, C. S. Welch, presented *1st Ann. Mtg. Intl. Omega Assoc.*, Arlington, Va., July 27-29, 1976.

161-09880-400-60

A TIDAL PRISM MODEL

(*b*) Virginia State Water Control Board.
(*c*) A. Y. Kuo, Assoc. Marine Scientist.
(*e*) An empirical theory was developed to calculate the equilibrium distribution of pollutants introduced into an estuarine system. The theory was adapted from Ketchum's modified tidal prism method for predicting flushing time in an estuary. The application of this method requires that there be complete mixing at high tide within each segment. The model, which was applied to the Pagan River, was derived from the principle of mass balance.
(*f*) Completed.

(*g*) The model was used to calculate high water salinity concentration throughout the estuary so that the predicted results could be compared with actual field data. Having verified the model in this way, other conservative pollutants can be used as input so that a high tide concentration of these substances can be calculated.
(*h*) **Development of a Tidal Prism Model and Its Applications to the Pagan River, Virginia,** A. D'Amico, *Master's Thesis*, College of William and Mary, 1976.

161-09881-400-60

THE DEVELOPMENT OF A NEAR-FIELD MODEL FOR THE PREDICTION OF POLLUTANT DISTRIBUTION IN ESTUARIES

(*b*) Virginia State Water Control Board; McGaughy, Mashall & McMillan–Hazen and Sawyer.
(*c*) A. Y. Kuo, Assoc. Marine Scientist.
(*d*) Field investigation, theoretical, applied research.
(*e*) A method was developed for predicting the distribution of sewage constituents which would result from a proposed sewage outfall in estuaries or coastal seas. The method is based on the mathematical relationship between the solutions of the mass balance equations with and without a decay term and on the assumption that both the dispersion and decaying processes are linear, acting independently. The application of the method requires dye dispersion experiments and a numerical model employing the results of the experiments. This approach makes it possible to predict the concentration field of sewage constituents with differing decay rates by using a tracer release experiment employing a conservative tracer.
(*f*) Completed.
(*g*) The method has been applied to assess the environmental impact of a proposed sewage outfall in Hampton Roads, Virginia. Two dye dispersion experiments were performed. The results were used to predict the concentration fields of total nitrogen, total phosphorus, coliform bacteria, biochemical oxygen demand, dissolved oxygen deficit and chlorine residuals, which would result from the proposed sewage outfall.
(*h*) **Prediction of Pollutant Distribution in Estuaries,** A. Y. Kuo, J. P. Jacobson, *Proc. 15th Intl. Conf. Coastal Engrg.*, 1976.

161-09882-400-60

CHINCOTEAGUE BAY SYSTEM HYDROGRAPHICAL AND WATER QUALITY SURVEY STUDY

(*b*) Maryland Department of Natural Resources; Virginia State Water Control Board.
(*c*) P. V. Hyer, Assoc. Marine Scientist.
(*d*) Field investigation, applied research.
(*e*) A joint project involving the states of Virginia, Maryland, and Delaware was carried out to quantify the existing water quality of and the non-point pollution sources into the Chincoteague-Sinepuxent-Isle of Wight-Assawoman Bay complex. VIMS reviewed and analyzed existing physical, biological, and chemical data which was used to design a detailed sampling program of the coastal basin. VIMS plans to supervise, and coordinate all field surveys as outlined in the sampling program. The data collected will be used for calibrating and verifying a water quality computer model of the Bay system for use in prevention, control, and abatement of pollution and for wasteload allocation.
(*h*) **Index of Existing Data Sources for Chincoteague, Sinepuxent, Assawoman and Little Assawoman Bays,** P. V. Hyer, J. P. Jacobson, C. S. Fang, *Report to the Maryland Department of Natural Resources*, Nov. 1975.

161-09883-490-52

INVESTIGATION OF ENVIRONMENTAL EFFECTS OF SALINITY GRADIENT AND OCEAN WAVE ENERGY CONVERSION

(*b*) Energy Research and Development Administration.
(*c*) P. V. Hyer, Assoc. Marine Scientist.
(*d*) Theoretical, applied research.
(*e*) Project dealt with wave and salinity gradient energy conversion. A resulting report was concerned with the environmental effects such power projects might have on the coastal zone.
(*f*) Completed.
(*h*) **Environmental Effects Arising from Salinity Gradient and Ocean Wave Power Generating Plants,** J. M. Zeigler, P. V. Hyer, M. L. Wass, presented *ERDA Wave and Salinity Gradient Energy Conversion Workshop*, Newark, Del., May 24-26, 1976.

161-09884-400-00

A MODEL OF CHINCOTEAGUE BAY WITH APPLICATIONS

(*c*) C. S. Fang, Department Head and Senior Marine Scientist.
(*e*) A two-dimensional vertically averaged hydrodynamic model was applied to Chincoteague Bay, Virginia. The model yielded current velocities in the horizontal plane and water elevations due to tidal input. This was coupled to a water quality model for conservative and nonconservative properties.
(*f*) Completed.
(*h*) **Hydrography and Hydrodynamics of Virginia Estuaries, X. A Mathematical Model of Chincoteague Bay, Virginia,** J. Jacobson, J. Vaccaro, *Vims Sramsoe* **121**, Sept. 1976. *Master's Thesis*, John Vaccaro, College of William and Mary.

161-09885-400-73

BATHYMETRIC STUDY OF LOWER YORK RIVER ADJACENT TO VEPCO YORKTOWN POWER STATION

(*b*) Virginia Electric and Power Company.
(*c*) C. S. Fang, Department Head and Senior Marine Scientist.
(*d*) Field investigation.
(*e*) VIMS performed three comprehensive nearshore bathymetric surveys of the York River adjacent to the Yorktown Power Station. These surveys were carried out just prior to installation of a new discharge pipe-diffuser system, just after completion of the pipe-diffuser and two years after the system had been in place.
(*f*) Completed.
(*h*) Three survey reports supplied to VEPCO and the Army Corps of Engineers, Norfolk District.

161-09886-870-68

YORK RIVER STP RECIRCULATION DYE STUDY

(*b*) Hampton Roads Sanitation District Commission.
(*c*) C. S. Fang, Department Head and Senior Marine Scientist.
(*d*) Field investigation.
(*e*) The use of the VEPCO outfall on the York River by the Hampton Roads Sanitation District to discharge treated waste water was under consideration. During part of the tidal cycle, a portion of effluent plume is entrained into the intake. Recirculation of the STP (sewage treatment plant) effluent could pose a problem although none was anticipated for the thermal discharges. The purpose of the project was to determine what percentage of the water is recirculated by introducing dye into the effluent and measuring the concentration in the intake.
(*f*) Completed.

161-09887-870-68

DAM NECK CURRENT ANALYSIS

(*b*) Hampton Roads Sanitation District Commission through Malcolm Pirnie Engineers.
(*c*) C. S. Welch, Assoc. Marine Scientist.
(*d*) Experimental, applied research.
(*e*) An analysis of current meter data gathered by EG&G during summer and fall 1973 offshore from Virginia Beach, Va., is being performed. The object of the analysis is the determination of current parameters of interest in design and construction of a sewage treatment plant outfall diffuser. Those discussed include mean current, tidal ellipses

for the M_2 tide, currents during winter storms, definition of the winter storm season and currents during hurricanes.
(*h*) **Dam Neck Current Analysis Study** (draft), C. Welch, submitted January 1977.

161-09888-450-34

ANALYSIS OF THE GULF STREAM INTERACTION IN THE SOUTH ATLANTIC BIGHT

(*b*) Department of Interior (Bureau of Land Management), Environmental Research Technology, Inc. (ERT).
(*c*) Chris Welch, Assoc. Marine Scientist.
(*d*) Theoretical, applied research, data interpretation.
(*e*) The strength of interaction between the Gulf Stream and the continental shelf between Cape Hatteras and Cape Canaveral is being investigated. The technique of investigation involves remote sensing data and analysis of hydrographic data. A report containing the estimates will be submitted to BLM via ERT.

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VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY, College of Engineering, Department of Civil Engineering, Blacksburg, Va. 24061. Dr. R. D. Walker, Department Head.

162-09170-860-33

MATHEMATICAL MODELING OF STREAMFLOW AND WATER QUALITY IN THE UPPER REACHES OF THE CHOWAN RIVER

(*b*) Office of Water Research and Technology.
(*c*) D. N. Contractor, Assoc. Professor.
(*d*) Theoretical; applied research; Master's thesis.
(*e*) Two computer programs have been developed. The first is an implicit flow-routing model for the Chowan River system. This program can take into account lunar and wind tides. The second is a program which solves for the concentration of the following water quality parameters: BOD, COD, phosphorus, dissolved oxygen and four nitrogen parameters (organic, ammonia, nitrite-nitrate, algal). The four nitrogen parameters are solved for simultaneously. The results from the computer program have been compared with measured field data and reasonable agreement was obtained.
(*g*) The results of the computer simulation show that algal concentrations can become very high in the summer months when the temperatures are high and the flows are low. The relative contribution of each major source of nutrients to the algal concentration has also been obtained.
(*h*) **Optimal River Crossections for Flood Routing,** V. Seetharama Rao, D. N. Contractor, C. Tiyamani, *Proc. Rivers 76, Symp. Inland Waterways for Navigation, Flood Control and Water Diversions, ASCE*, Fort Collins, Colo., Aug. 76, **I**, pp. 421-433.
Optimization of Parameters used in Routing Flood Flows in Rivers, V. Seetharama Rao, D. N. Contractor, C. Tiyamani, *Proc. 1976 Summer Computer Simulation Conf.*, Washington, D.C., pp. 249-254, July 1976.

162-09905-870-00

OXYGEN DEPLETION AND SULFATE PRODUCTION IN STRIP MINE SPOIL DAMS

(*c*) D. N. Contractor, Assoc. Professor or C. S. Desay, Professor.
(*d*) Theoretical and numerical analysis; Ph.D. degree.
(*e*) This study investigates the production of sulfates and the depletion of dissolved oxygen when water seeps through a dam constructed of strip mine spoil materials. The method of solution is a three-part finite element analysis. Part one deals with the steady state seepage problem involving the solution of the Laplacian of the piezometric head. Using this output, parts two and three solve the diffusion-convection equation, including a chemical reaction term, for the sulfate and dissolved oxygen concentrations.
(*f*) Completed.
(*g*) No field data was available to check the results of the computer program. Results are presented in the form of nodal concentrations of sulfate for specific reaction rates and diffusion coefficients. Summary curves are also presented giving the sulfate and oxygen concentrations of the effluent leaving the dam as a function of pyritic reaction rates and soil permeabilities.
(*h*) **Oxygen Depletion and Sulfate Production in Strip Mine Spoil Dams,** J. H. Amend, D. N. Contractor, C. S. Desai, *Numerical Methods in Geomechanics, 2nd Intl. Conf. VPI & SU*, Blacksburg, Va., pp. 1155-1167, June 1976. Proceedings published by ASCE.

162-09906-200-00

DETERMINATION OF MANNING'S COEFFICIENT FOR OVERLAND FLOW USING A FINITE ELEMENT MODEL

(*c*) D. N. Contractor, Assoc. Professor.
(*d*) Theoretical; applied research; Ph.D. thesis.
(*e*) Manning's coefficient "n" for open channel flows with vegetative growth are available in the technical literature. However, when routing rainfall excess over a watershed area, the appropriate "n" values to be used as a function of land use are not available. This study is directed at obtaining these values using an optimization technique together with a finite element model of overland flow. The South River watershed near Waynesboro, Va., is used as a test area. For a given rainfall, the program first calculates the rainfall excess and then routes the excess over the land and then in the stream. Comparisons are made between the computed and measured streamflows at Waynesboro. The error between these two curves is systematically reduced by the optimization technique. The optimized "n" values will be tested for validity using other storms.

162-09907-870-00

SIMPLE-INTEGRATED-MODULAR WATERSHED PLANNING MODEL

(*c*) D. N. Contractor, Assoc. Professor.
(*d*) Theoretical study; applied research; Doctoral thesis.
(*e*) The model attempts to develop a series of linked, modular programs which provide indicators of environmental quality and the ramifications associated with a broad range of land use development, environmental quality and budgetary objectives. The case study is one for the South River Watershed in Augusta County, Virginia.
(*g*) The simple, integrated, modular framework permits the modules of the model to evolve in response to the changing nature of the problems of the watershed when the model is being applied. Key objectives of the modeling strategy are to develop a model which can be employed by local and regional planning agencies and to limit data base requirements to those which can be maintained through existing sources of data. The four modules are: 1) Module I, Runoff and Routing; 2) Module II, Water Quality, as measured by DO, BOD, P; 3) Module III, TOPAZ (Sewer and Water Submodel), the infrastructure requirements in dollars associated with the land use plans and levels of water quality; and 4) Module IV, Goal Programming, a technique similar to linear programming which links the environmental quality objectives, priorities and costs to the broader public budgeting process. Tradeoffs associated with multiple watershed development objectives are made explicit thereby being more easily integrated into the decision process.

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VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY, Department of Mechanical Engineering, Blacksburg, Va. 24061. Dr. J. B. Jones, Department Head.

163-08363-030-00

THE INTERACTION OF THE WAKE OF A CYLINDER AND A FLAT-PLATE BOUNDARY LAYER

(*d*) Experimental; basic research partly for Doctoral thesis.

(*e*) A basic study has been made of the incompressible flow field 80 and more diameters downstream from a circular cylinder which is located with its axis normal to a flat plate on which a zero-pressure-gradient boundary layer is developing. The cylinder diameter is less than the boundary layer thickness, and the cylinder is essentially infinite in length.
(*f*) Completed.
(*g*) Secondary flows initiated by the stagnation pressure gradient on the upstream face of the cylinder affect the velocity distribution in the wake-boundary layer interaction region within approximately 100 cylinder diameters downstream of the cylinder. The interaction region as far as 200 diameters downstream has characteristics which are those of wakes and boundary layers in approximately equal proportions.

163-08367-550-20

INVESTIGATION OF PRESSURE FLUCTUATIONS AND STALLING CHARACTERISTICS ON ROTATING AXIAL-FLOW COMPRESSOR BLADES

(*b*) Office of Naval Research–Project SQUID.
(*c*) Dr. W. F. O'Brien, Assoc. Professor; Dr. H. L. Moses, Professor.
(*d*) Experimental and analytical; applied research for Master's and Doctoral theses.
(*e*) Radio-telemetry techniques have been developed for the transmission of flow data from the rotating blades of an axial-flow compressor. Of special interest are the blade surface pressures under off-design and stall conditions. The analytical approach includes the inviscid flow and boundary layer interaction.
(*g*) A six-channel telemetry system has been developed for the simultaneous transmission of six pressure signals from transducers embedded in the rotor blade. Chord-wise pressure distributions (both mean and fluctuating) have been measured at different radial positions for various flow rates, including stall. Current experiments are conducted on a relatively low-speed compressor. A new high-speed research facility has been constructed which will provide for similar experiments on state-of-the-art compressor rotors.
(*h*) **The V. P. I. Gas Turbine and Turbomachinery Research Laboratory,** W. F. O'Brien, H. L. Moses, R. R. Jones, J. F. Sparks, *ASME Paper No. 77-GT-73*, 1977.

163-09184-550-70

TRANSONIC NOZZLE FLOW METHODS

(*b*) Douglas Aircraft Co., McDonnell Douglas Corporation.
(*c*) Dr. E. F. Brown, Assoc. Professor.
(*d*) Theoretical; applied research for Master's thesis.
(*e*) Develop a fast and accurate computational method for predicting the performance of aircraft propulsion nozzles using the method of type-dependent relaxation.
(*g*) For a convergent-divergent nozzle of hyperbolic geometry the calculated lines of constant Mach number were in excellent agreement with a previously published series expansion solution. These results were obtained in approximately one-tenth of the time which would be required for a solution by time dependent methods. Runs have also been made with a wide range of aircraft propulsion nozzle geometries.
(*h*) **A Survey of Methods for Exhaust-Nozzle Flow Analysis,** E. F. Brown, G. L. Hamilton, *J. Aircraft* **13,** 1, pp. 4-11, Jan. 1976.
A Relaxation Method for the Solution of Rotational Transonic Nozzle Flow, T. Brecht, *Masters Thesis*, Va. Polytechnic Inst. and State Univ., Aug. 1975.
A Relaxation Solution of Transonic Nozzle Flows Including Rotational Flow Effects, *AIAA Paper No. 76-674*, July 1976.

163-09185-000-54

NEAR-WALL SIMILARITY IN THREE-DIMENSIONAL FLOWS

(*b*) National Science Foundation.
(*c*) Dr. F. J. Pierce.
(*d*) Experimental.
(*e*) Direct measurements of local wall shear stress with velocity field data emphasizing near-wall measurements and pressure field data will be studied to determine the existence and limits on hypothesized near wall similarity in three-dimensional turbulent flows.

163-09187-600-12

INVESTIGATION OF THE EFFECTS OF GEOMETRICAL CHANGES DUE TO CONTAMINATION ON FLUIDIC COMPONENT PERFORMANCE

(*b*) Harry Diamond Laboratories.
(*c*) Dr. H. L. Moses, Professor.
(*d*) Experimental; applied research for Master's thesis.
(*e*) Experiments were conducted on a fluid amplifier in which there were known amounts of contaminant deposits at different points. An effort is being made to correlate changes in performance with these geometrical changes.
(*f*) Completed.
(*h*) **The Effect of Geometric Changes Due to Contamination on Fluid Amplifier Performance,** H. L. Moses, E. Sancaktar, *Harry Diamond Laboratories, HDL-CR-75-192-1, Final Rept.*, Contract No. DAAG 39-74-C-0192, Nov. 1975.

UNIVERSTIY OF VIRGINIA, Chemical Engineering Department, Charlottesville, Va. 22901. Dr. J. L. Hudson, Chairman.

164-10015-120-00

VISCOELASTIC FLUID BEHAVIOR

(*c*) Dr. L. U. Lilleleht, Assoc. Professor.
(*d*) Experimental and theoretical for Doctoral theses.
(*e*) Investigation of the kinematics and the stress fields near the stagnation point with polyisobutylene solutions flowing in T-shaped and in expanding/contracting channels.
(*f*) Temporarily suspended.
(*g*) Velocity field was determined by Laser-Doppler-Anemometry and the normal stress differences by flow birefringence. These data were used to evaluate a number of constitutive equations. A "stagnant" zone of finite thickness was detected near the stagnation point.
(*h*) **The Behavior of Viscoelastic Fluids in Stagnation Flow,** P. J. Leider, *Ph.D. Dissertation*, U. Va. Library, May 1972.
Viscoelastic Behavior in Stagnation Flow, P. J. Leider, L. U. Lilleleht, *Trans. Soc. Rheology* **17:3,** 501-524, 1973.
Kinematics of Plane Stagnation Flow, A. Berker, *Ph.D. Dissertation*, U. Va. Library, Nov. 1975.
Wiggle Flow of a Viscoelastic Fluid, Mahir Arikol, *Ph.D. Dissertation*, U. Va. Library, May 1976.

VOUGHT CORPORATION ADVANCED TECHNOLOGY CENTER, INC., P.O. Box 6144, Dallas, Tex. 75222. Dr. F. W. Fenter, President and Chairman of the Board.

165-09925-250-20

COMPLIANT WALL DRAG REDUCTION

(*b*) Office of Naval Research.
(*c*) Dr. C. H. Haight, Mgr.-Aerodynamics and Propulsion.
(*d*) Experimental; basic research.
(*e*) Evaluate systematically the effects of compliant membrane/substrate properties on turbulent skin friction. This is directed towards the achievement of a practical means for reducing drag on hydrodynamic vehicles.

(*g*) Rotating disk tests of compliant surfaces completed and documented. Water tunnel tests of compliant flat plates in progress.

(*h*) **Hydrodynamic Drag of Disks with Compliant Membrane/Substrate Faces,** T. D. Reed, *Advanced Technology Center, Inc. Rept. No. B-94300/7CR-1,* Jan. 1977.

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WASHINGTON STATE UNIVERSITY, The R. L. Albrook Hydraulic Laboratory, Department of Civil and Environmental Engineering, Pullman, Wash. 99164. Professor John A. Roberson, Laboratory Head.

166-08375-210-54

FLOW IN ROUGH CONDUITS

(*d*) Experimental and theoretical; basic research for Ph.D. theses.

(*e*) Previous basic research has developed the method for predicting the resistance to flow in artificially roughened conduits and in rock bedded streams. This research is primarily focused on developing the method to analytically predict the resistance in commercially rough conduits.

(*g*) Initial developments indicate that the method has promise for commercially rough pipes.

(*h*) **A Statistical Roughness Model for Computation of Large Bed-Element Stream Resistance,** R. Calhoun, *Ph.D. Thesis,* Washington State University, 1975.

166-09189-280-60

AIR ENTRAINMENT CHARACTERISTICS OF PLUNGING WATER JETS

(*b*) Washington State Department of Ecology.

(*c*) Alan F. Babb, Assoc. Hydraulic Engineer; Walter C. Mih, Assoc. Hydraulic Engineer.

(*d*) Experimental; basic research; M.S. thesis.

(*e*) Study of the fluid mechanics of the air entrainment of plunging water jets. Experiments have been made on two-dimensional jets and methods have been developed to measure air concentration using the principles of gamma ray attenuation and hot film anemometry.

(*h*) **Air Entrainment Characteristics of Plunging Water Jets and their Relationship with Nitrogen Supersaturation in Rivers–Instrument Development,** A. F. Babb, W. C. Mih, H. C. Aus, submitted to the Washington State Department of Ecology, Olympia, Wash., 31 pages, Dec. 31, 1974. Available Albrook Hydraulics Laboratory, Washington State University, Pullman, Wash. 99164.

166-09196-340-73

HYDRAULIC MODEL STUDIES OF ROCK TRAPS–HELMS PUMPED STORAGE PROJECT

(*b*) Pacific Gas and Electric Company.

(*c*) Claud C. Lomax, Hydraulic Engineer.

(*d*) Experimental; applied research.

(*e*) Alternate bids on the tunnel construction resulted in a tunnel shape not previously tested. The project has been extended to study the surge tank orifice coefficients for two surge tank orifices and to study the effectiveness of the rock trap in the tunnel selected for construction.

166-09197-800-33

INSTREAM FLOW NEEDS IN THE PACIFIC NORTHWEST: A REGIONAL STUDY OF INSTITUTIONAL AUTHORITY, METHODOLOGY AND INFORMATION RETRIEVAL

(*b*) Office of Water Research and Technology.

(*c*) John F. Orsborn, Chairman and Professor, Dept. of Civil and Environmental Engineering.

(*d*) Assessment of the legal, political, biological, and engineering aspects.

(*e*) To address the work which has been done and is planned, on the problem of reserving flows in streams for such needs as fisheries, recreation, and aesthetics. The analysis of this regional problem includes a collection, collation, assessment of legal, political and methodological components of the total problem. Workshops for practitioners have been held and an information dissemination system for this user group is being developed.

(*f*) Completed.

(*g*) Numerous operational problems have been identified through the workshops, questionnaires and personal interviews. A few of these include lack of communication and coordination between regional program participants in state and federal agencies, as well as within agencies and within states; the need for incremental flow methodology to evaluate tradeoffs for competing uses of the stream; new laws without funds to enforce, and short time frames within which to preserve flows; and a lack of quantification of flow diversions out-of-stream.

(*h*) Report on workshops held in Sept. and Oct., 1974, for distribution to participants, Jan. 1975.
Project Report to OWRT, Apr. 15, 1975.
Reports will be available from State of Washington Water Research Center, Wash. State Univ., Pullman, Wash. 99163.

166-09198-860-60

HYDRAULIC AND WATER QUALITY RESEARCH STUDIES AND ANALYSIS OF CAPITOL LAKE SEDIMENT AND RESTORATION PROBLEMS, OLYMPIA, WASHINGTON

(*b*) Washington State Department of General Administration.

(*c*) John F. Orsborn, Chairman and Professor, Dept. of Civil and Environmental Engineering.

(*d*) Field; laboratory; hydraulic model and computer model analysis.

(*e*) The first phase of the study has dealt with an analysis of the sediment entering Capitol Lake from the Deschutes River. Hydraulic model studies have been conducted to determine how to dredge the Upper Lake to trap sediment and keep it out of the Middle and Lower Lakes. Hydrologic analyses, coupled with hydraulic model dye dispersion and detention studies will provide water quantity information for the water quality prediction model. Field tests of bottom muds and water quality conditions have been conducted by the Environmental Research Section.

(*f*) Completed.

(*g*) Design geometry for dredging the Upper Lake to trap sediment has been determined through field and hydraulic model studies. Also, method of estimating future sediment load based on precipitation for accounting procedures of maintenance dredging have been determined. Dredging of the rest of the lake will be done to depths needed to remove nutrient-rich bottom muds, to minimize weed growth, and optimize boating safety and usability.

(*h*) Preliminary Report on a **Sediment Removal and Maintenance System for the Upper Basin of Capitol Lake, Olympia, Washington,** Aug. 15, 1974., **Supplement No. 1,** Sept. 6, 1974, **Supplement No. 2,** Sept. 13, 1974, W. C. Mih, J. F. Orsborn; **Summary Report,** Dec. 20, 1974, J. F. Orsborn.

166-09199-800-88

WATER RESOURCES OF THE COEUR D'ALENE INDIAN RESERVATION

(*b*) Coeur d'Alene Indian Tribal Council.

(*c*) John F. Orsborn, Chairman and Professor, Dept. of Civil and Environmental Engineering.

(*d*) Field, laboratory, and analytical investigation.

(*e*) The various phases of the project include the determination areal precipitation distribution; gaged and ungaged stream flows in subbasins; floods, average and low flows; geologic investigations; well testing; analysis of groundwater level records; summary of existing water rights; and potential water resources available.

(*f*) Completed.

(*g*) Field data acquisition is complete and analytical work is underway.

(*h*) Final project report due June 30, 1975.

166-09200-030-54

EFFECTS OF TURBULENCE ON DRAG AND VIBRATION OF ANGULAR BODIES

(*b*) National Science Foundation.
(*c*) John A. Roberson, Professor and Hydraulic Engineer.
(*d*) Experimental basic research; M.S. and Ph.D. theses.
(*e*) Investigate the effect of free-stream turbulence on the pressure distribution, drag and vibration of angular bodies.
(*g*) The most recent research has focused on the effects of turbulence on bodies of finite length whereas earlier research was concentrated on two-dimensional bodies.
(*h*) **Aeroelastic Response of Square and H-Sections in Turbulent Flows,** J. Tai, C. T. Crowe, J. A. Roberson. Contributed by the *Fluids Engrg. Div. of the ASME for presentation at the Winter Ann. Mtg.*, N. Y., Dec. 5, 1976, 76-WA/FE-19, 4 pages, Aug. 11, 1976. Copies available until Sept. 1, 1977 through ASCE, United Engrg. Center, 345 E. 47th St., N.Y., N.Y. 10017. $3.00 per copy, $1.50 to ASME members.

166-10131-390-60

LITERATURE SEARCH ON THE RESTORATION OF STREAM GRAVEL FOR SPAWNING & REARING OF SALMON SPECIES

(*b*) Washington State Department of Fisheries.
(*c*) Walter C. Mih, Assoc. Professor and Hydraulic Engineer.
(*d*) Applied research.
(*e*) This was the initial phase of a study to develop new and practical methods for restoration of salmon spawning and rearing beds in natural streams. When large amounts of fine material are present in the intragravel spaces, the growth of eggs and alevins will be severely limited due to lack of oxygen and nutrition. This study is to search the literature and communicate with people who have been active in spawning bed maintenance. Particular attention will be focused on the cleaning of stream by hydraulic jet action.
(*f*) Completed.
(*g*) The second phase, laboratory testings to determine a suitable jet-suction system, will be carried out in 1977.

166-10132-300-34

HYDRAULIC CHARACTERISTICS OF THE YAKIMA RIVER FOR ANADROMOUS FISHERIES

(*b*) U.S. Fish & Wildlife Service, Columbia River Fisheries Program.
(*c*) Howard D. Copp, Professor and Hydraulic Engineer.
(*d*) Field investigation, applied research, development.
(*e*) Determine stream flowrates that are conducive to spawning and rearing by Pacific Salmon species in the Yakima River, Washington. Systematic measurement of velocities and depths at various flowrates have been made over a period of 18 months. Comparing these with known spawning and rearing habitat of the species, preferred spawning and rearing discharges have been identified at eight locations along the 200 mile river.
(*g*) Existing flow regimes are conducive to spawning and rearing in most locations studied. In some instances, regulated low flows may have to be increased. Riverbed erosion and deposition would hinder egg survival in certain locations.
(*h*) In preparation, available about July 1, 1977.

166-10133-350-73

HYDRAULIC MODEL STUDY OF CABINET GORGE HYDROELECTRIC PROJECT PERFORMANCE

(*b*) Washington Water Power Company.
(*c*) Howard D. Copp, Professor and Hydraulic Engineer.
(*d*) Experimental, applied research, operations.
(*e*) Spillway operation on the Clark Fork River, Idaho, has caused considerable erosion of concrete in the plunge pool at the base of the concrete arch dam. Experiments were made to learn about the mechanics of falling jets into the deep pool and the dissipation of energy in the pool as it related to erosion of concrete. Remedial measures were sought also.
(*f*) Completed.
(*g*) Erosion causes were determined. The plunging jet created two vertical eddies; one was located immediately above the riverbed below the plunge pool which entrained stones and small boulders. These were forced into the plunge pool where the other eddy rolled them continously along concrete surfaces. Elimination of future erosion requires costly construction or, in some cases, tight control on spillway and power unit operation.
(*h*) **Hydraulic Model Studies of the Cabinet Gorge Plunge Pool Basin,** H. D. Copp, *Research Rept. 13J-3815-1376*, College of Engrg., Washington State Univ., Pullman, Wash., 69 pp., 1976.

166-10134-300-88

LOW FLOW AUGMENTATION OF THE UMATILLA RIVER FOR ANADROMOUS FISH SPECIES

(*b*) Confederated Tribes of the Umatilla Indian Reservation.
(*c*) Howard D. Copp, Professor & Hydraulic Engineer.
(*d*) Experimental, theoretical, applied research.
(*e*) Hydrologic water balances are being developed for several watersheds comprising the Umatilla basin above Pendleton, Oregon. Existing runoff patterns are being developed and will be compared with those required for spawning and rearing by anadromous fish. Water availability for augmentating low summer flows and streamflow regulation possibilities are being studied.

166-10440-350-75

HYDRAULIC MODEL STUDY OF THE BOARDMAN RESERVOIR SPILLWAY

(*b*) Bechtel Incorporated, San Francisco, California.
(*c*) Alan F. Babb, Professor and Hydraulic Engineer.
(*d*) Experimental, applied research; development.
(*e*) The head-discharge relationship for a labyrinth weir was developed in a model to provide water surface control for a thermal powerplant cooling reservoir. Fluctuating pressures, chute training wall requirements and erosion characteristics downstream from a dissipator structure were also studied.
(*f*) Completed.
(*h*) **Hydraulic Model Study of the Boardman Reservoir Spillway, Project Report,** A. F. Babb. Available Albrook Hydraulics Laboratory, Washington State University, Pullman, Wash. 99164.

166-10441-350-73

MORRIS DAM AND SPILLWAY FLOOD PASSING CAPABILITY

(*b*) Metropolitan Water District of Southern California.
(*c*) Alan F. Babb, Professor and Hydraulic Engineer.
(*d*) Experimental, applied research; development.
(*e*) Investigation of methods to permit overtopping of a concrete dam to pass flood flows.
(*f*) Completed.
(*h*) **Morris Dam and Spillway Flood Passing Capability, Project Report,** A. F. Babb. Available Albrook Hydraulics Laboratory, Washington State University, Pullman, Wash. 99164.

UNIVERSITY OF WASHINGTON, Department of Civil Engineering, Seattle, Wash. 98195. Professor R. O. Sylvester, Department Chairman.

167-09204-470-60

RELATIONSHIP OF FLUSHING AND WATER QUALITY CHARACTERISTICS OF SMALL-BOAT MARINAS

(*b*) State of Washington Water Research Center (1973-74); State of Washington Department of Ecology (1974-75).
(*c*) Professor R. E. Nece, or Professor E. B. Welch.
(*d*) Experimental and field investigation; applied research.
(*e*) Determine to what extent tidal flushing characteristics of enclosed small-boat marinas can be related to water quali-

ty within the marinas, and more specifically, to determine how well the marina flushing characteristics as determined from small-scale hydraulic models serve as predictors for relative alterations in significant water quality parameters. Existing marinas in Puget Sound are to be studied through laboratory models to obtain hydraulic performance and by routine field sampling of the quality parameters.

(*f*) Completed.

(*h*) **Flushing Criteria for Salt Water Marinas,** R. E. Nece, E. B. Welch, J. R. Reed, *C. W. Harris Hydraulics Lab Tech. Rept. 42*, June 1975.

Application of Physical Tidal Models in Harbor and Marina Design, R. E. Nece, E. P. Richey, *Proc. Symp. Modeling Techniques, ASCE*, San Francisco, Calif., pp. 783-799, Sept. 1975.

167-09205-430-44

FLOATING BREAKWATER RESEARCH

(*b*) National Oceanic and Atmospheric Administration, Sea Grant Program.

(*c*) Professor E. P. Richey, or Professor B. H. Adee, Dept. of Mechanical Engineering.

(*d*) Experimental and theoretical; both basic and applied research.

(*f*) Completed.

(*e*) Studies include design of instrument package for acquisition of field data on performance characteristics of floating breakwaters, data acquisition, and development of a two-dimensional mathematical model for predicting breakwater performance characteristics using the basic theoretical approach.

(*g*) Reported in (h).

(*h*) **Theoretical Analysis of Floating Breakwater Performance,** B. H. Adee, W. Martin, *1974 Floating Breakwaters Conf. Papers*, pp. 21-41, 1974.

Prototype Performance Characteristics of a Floating Breakwater, D. Christensen, E. P. Richey, *1974 Floating Breakwaters Conf. Papers*, pp. 159-181, 1974.

167-09206-430-11

FLOATING BREAKWATER FIELD ASSESSMENT PROGRAM, FRIDAY HARBOR, WASHINGTON

(*b*) U.S. Army Coastal Engineering Research Center.

(*c*) Professor E. P. Richey, or Professor B. H. Adee, Dept. of Mechanical Engineering.

(*d*) Experimental and theoretical; basic and applied research.

(*e*) An extension of the basic steps in part (e) of 175-09205-430-44 to a particular site with extensions of theory to examine non-linear aspects and with an initial step in generalizing floating breakwater performance characteristics and design criteria.

(*f*) Completed.

(*g*) Reported in (h).

(*h*) **Floating Breakwater Field Assessment Program, Friday Harbor, Washington,** B. H. Adee, E. P. Richey, D. R. Christensen, *U.S. Army Corps of Engrs. Coastal Engrg. Res. Center, Tech. Paper No. 76-17*, Oct. 1976, Fort Belvoir, Va. 22060.

167-10182-410-00

TIDAL INLET STUDIES

(*c*) Professor E. P. Richey or Professor R. E. Nece.

(*d*) Field investigation, basic research; Master's thesis.

(*e*) Field studies of the hydraulics of two half-tidal inlets on Puget Sound, Washington. Attention focused on stability of inlets across gravel beaches.

(*h*) **Hydraulics of Two Small Gravelly Tidal Inlets,** D. Simpson, *M.S. Thesis*, 1976.

Changes in Beach Equilibrium Caused by a Backwater at a Small Tidal Inlet, A. Murray, *M.S. Thesis*, in process.

167-10183-470-13

MIXING AND FLUSHING CHARACTERISTICS OF SQUALICUM SMALL BOAT BASIN

(*b*) Dept. of the Army, Corps of Engineers, Seattle District.

(*c*) Professor E. P. Richey.

(*d*) Experimental, applied research; Master's thesis.

(*e*) Design of basin with regard to optimization of tidal flushing action and internal mixing.

167-10184-860-60

CORRELATION OF WATER QUALITY AND HYDRAULIC PARAMETERS IN BIRCH BAY MARINA

(*b*) Washington State Department of Fisheries.

(*c*) Professor E. P. Richey.

(*d*) Experimental and basic research; Master's thesis.

(*e*) Correlate hydraulic parameters as dependent upon tidal action with water quality parameters important to fish and shell fish in the marina.

167-10185-870-61

EFFECTIVENESS OF FLUSHING AND SEWAGE TREATMENT IN MOSES LAKE EUTROPHICATION CONTROL

(*b*) State of Washington Water Research Center.

(*c*) Professor R. E. Nece, or Professor E. B. Welch.

(*d*) Experimental, applied research.

(*e*) A physical hydraulic model of lower Moses Lake, Washington, was constructed and tests conducted to determine the flushing achieved in the lake due to pulsed inflows of freshwater which could be delivered to the lake through an existing irrigation canal system. Flushing results were to be correlated with water quality models and prior field measurements in Moses Lake to estimate the relative effectiveness of proposed flushing schedules.

(*f*) Completed.

(*h*) **Dilution for Eutrophication Control in Moses Lake: Hydraulic Model Study,** R. E. Nece, J. R. Reed, E. B. Welch, *C. W. Harris Hydraulics Lab. Tech. Rept. No. 49*, July 1976.

167-10186-470-00

PLANFORM GEOMETRY INFLUENCE ON FLUSHING OF SMALL HARBORS

(*c*) Professor R. E. Nece, Director, C. W. Harris Hydraulics Laboratory.

(*d*) Experimental, applied and basic research; Master's thesis.

(*e*) Laboratory study to examine relationships of planform geometry (length-width ratio, entrance width) on the overall tidal flushing and interior circulation patterns of small constructed, enclosed, single-entrance harbors.

(*f*) Completed.

(*h*) **Tidal Circulation Effects in Rectangular Harbors,** R. A. Falconer, *M.S. Thesis*, 1974.

Planform Geometry Influence on Flushing and Circulation in Small Harbors, R. E. Nece, R. A. Falconer, T. Tsutsumi, *Proc. 15th Conf. Coastal Engrg., ASCE*, Honolulu, Hawaii, July 1976 (in press).

167-10187-800-60

CONJUNCTIVE MANAGEMENT OF GROUND AND SURFACE WATERS

(*b*) State of Washington Department of Ecology (partial).

(*c*) Professor S. J. Burges.

(*d*) Theoretical and applied research.

(*e*) An extensive literature review was conducted to assess the state-of-the-art in conjunctive management. Categories of problems were identified together with numerous interdependencies. Current work is focused on use of optimization tools to explain impacts of management strategies and different water right structures upon yield from irrigated farms. A hypothetical case approach is used for sensitivity analyses.

(*g*) **Issues in Conjunctive Use of Ground and Surface Waters,** S. J. Burges, R. Maknoon, *Harris Hyd. Lab. Tech. Rept. No. 44*, 1975.
Issues in Conjunctive Use of Ground and Surface Waters, R. Maknoon, S. J. Burges, *Proc. AWWA 96th Ann. Conf.*, New Orleans, 1976.

167-10188-300-33

OPERATIONAL COMPARISON OF STOCHASTIC STREAMFLOW GENERATION PROCEDURES

(*b*) Office of Water Research and Technology.
(*c*) Professor S. J. Burges.
(*d*) Theoretical numerical experiments.
(*e*) Comparisons were made between Fast Fractional Gaussian Noise, ARMA (1.1) and ARMA-Markov models of long-term persistence in annual streamflow. Implications for storage reservoir design were identified in a series of papers.
(*f*) Completed.
(*h*) **Operational Comparison of Stochastic Streamflow Generation Procedures,** S. J. Burges, D. P. Lettenmaier, *Harris Hyd. Lab. Tech. Rept. No. 45*, 1975.
Operational Assessment of Hydrologic Models of Long-Term Persistence, D. P. Lettenmaier, S. J. Burges, *Water Resources Research* **13**, 1, pp. 113-124, 1977.
An Operational Approach to Preserving Skew in Hydrologic Models of Long-Term Persistence, D. P. Lettenmaier, S. J. Burges, *Water Resources Research* **13**, 2, 1977.
A Comparison of Annual Streamflow Models, S. J. Burges, D. P. Lettenmaier, *J. Hydraulics Div., ASCE*, 1977.

167-10189-810-00

ANALYSIS OF EXTREME HYDROLOGIC EVENTS

(*c*) Professor S. J. Burges.
(*d*) Theoretical numerical analysis.
(*e*) A linear programming formulation was used to determine the maximum (or minimum) probability associated with a given magnitude event subject to satisfying moments and a unimodal spline approximated density function.
(*h*) **A Linear Programming Approach to Estimating Probability Bounds for Extreme Flood Events,** J. O. Noetzelman, *M.S. Thesis*, 1976.

167-10190-870-33

ANALYSIS OF RUNOFF DETENTION IN URBAN AND SUBURBAN WATERSHEDS

(*b*) Office of Water Research and Technology.
(*c*) Professor S. J. Burges.
(*d*) Theoretical and applied research.
(*e*) Research involved investigating the consequences of runoff control ordinances that require runoff peak flows after development to equal those before development. Porous pavements were investigated as one method for providing runoff control.
(*f*) Completed.
(*g*) Principal conclusions show that blanket control ordinances can significantly worsen downstream flood problems.
(*h*) **Some Consequences of Area-Wide Runoff Control Strategies in Urban Watershed,** R. A. Hardt, S. J. Burges, *Harris Hydraulics Lab. Tech. Rept. No. 48*, 1976.
Use of Porous Pavements in Urban Watersheds as a Peak Runoff Mitigation Measure, C. Olivers, *M.S. Thesis*, 1976.

167-10191-860-00

EXAMINATION OF THE NATURE OF WATER SUPPLY DEFICITS

(*c*) Professor S. J. Burges.
(*d*) Theoretical basic and applied research.
(*e*) Physical measures, notably probability distributions and conditional distributions of the magnitudes and durations of supply deficits for a single facility, are sought to give design information not currently used.
(*g*) Results have been obtained for annually operated facilities where input follows a lag-one Markov model. Further work is to be done for seasonally distributed flows and for flows exhibiting long term persistence.
(*h*) **An Empirical Investigation into the Nature of Water Supply Deficits Experienced in a Single Purpose Reservoir System,** N. R. Stefero, *M.S. Thesis*, 1977.

167-10192-870-00

OPTIMAL DESIGN OF STORMWATER SEWER SYSTEMS

(*c*) Professor S. J. Burges.
(*d*) Theoretical basic and applied research.
(*e*) Feasibility was demonstrated for completely incorporating unsteady hydrograph routing (implicit scheme) into a dynamic programming model to determine least cost combinations of major conduit elements and storage units for major storm sewer design. The approach requires preliminary plan location of the conveyance links and accurate estimates of inlet hydrographs.
(*f*) Completed.
(*h*) **Least Cost Control Strategies in Urban Drainage Design–A Dynamic Programming Approach,** S. Froise, *Harris Hydraulics Lab Tech. Rept. No. 46*, 1975.

167-10193-810-33

IMPROVING RESERVOIR OPERATION THROUGH FORECASTING INTRASEASONAL SNOWMELT RUNOFF

(*b*) Office of Water Research and Technology; City of Seattle; State of Washington Department of Ecology.
(*c*) Professor S. J. Burges.
(*d*) Theoretical basic and applied research.
(*e*) The worth of a forecast is estimated by using a change constrained linear programming formulation of reservoir operation. Economic returns from forecasts having differing refinements are estimated. Snowmelt models are examined (and will possibly be modified to explicitly incorporate uncertainty propagation) to determine which are appropriate for incorporation into prediction schemes and reservoir operation models.

167-10194-470-75

TIDAL CIRCULATION STUDY, PROPOSED SOUTHEAST HARBOR DEVELOPMENT, SEATTLE

(*b*) CH2M-Hill, Inc., Bellevue, Washington.
(*c*) Professor R. E. Nece, Director, C. W. Harris Hydraulics Laboratory.
(*d*) Experimental, applied research.
(*e*) Changes in tidal currents at the mouth of the Duwamish River Estuary in Elliott Bay, Seattle, were studied for various pier revision and fill extension proposals by physical model tests.
(*f*) Completed.
(*h*) **Tidal Circulation Study, Proposed Southeast Harbor Development,** R. E. Nece, R. Lowthian, *C. W. Harris Hydraulics Lab Tech. Rept. No. 47*, Jan. 1976.

UNIVERSITY OF WASHINGTON, Department of Mechanical Engineering, Seattle, Wash. 98195. Dr. Morris E. Childs, Chairman.

168-10072-700-40

MEASUREMENT OF FLUID TURBULENCE BASED ON PULSED ULTRASONIC TECHNIQUES

(*b*) National Institutes of Health (NIH).
(*c*) J. E. Jorgensen, Assoc. Professor; F. K. Forster, Research Associate; J. L. Garbini, Research Assistant.
(*d*) Theoretical investigation with experimental comparison.
(*e*) Theoretical study involves stochastic modeling of the pulsed ultrasonic Doppler velocimeter for turbulent flow with the aim of determining feasibility limits for the measurement of turbulence spectra and related parameters. The model results are compared with experimental ul-

trasonic and hot-film measurements of pipe flow turbulence. Improved procedures using dual-measurement-point techniques are also being investigated.

(*g*) Early results indicate good experimental agreement with the model and that practical uses for ultrasonic measurement of turbulence exist.

(*h*) **Hemodynamic Turbulence Measurements Using Ultrasonic Techniques,** F. K. Forster, J. L. Garbini, *Proc. 4th New England Bioengrg. Conf.*, Pergamon Press, May 7-8, 1976.

168-10073-520-54

FLUID FLOW AROUND SHIP HULLS

(*b*) National Science Foundation.
(*c*) Bruce H. Adee, Assoc. Professor.
(*d*) Theoretical.
(*e*) Flow around ship hulls is computed under the assumption that the fluid is inviscid. Comparisons are drawn between computed results and previous experimental results for the wave profile, streamlines and pressure distribution at constant forward speed.
(*f*) Completed.
(*h*) **An Investigation of the Fluid Flow About Ships,** K. Fung, *National Technical Information Service* (*RB261084/AS*).
Fluid Flow Around a Ship's Hull, *Proc. 1st Intl. Conf. Numerical Ship Hydrodynamics*, 20-22 Oct. 1975.
Wave-Making and Frictional Resistance of Practical Ship Forms, *Intl. Sem. on Wave Resistance*, Japan, Feb. 1976.

168-10074-430-44

FLOATING BREAKWATER RESEARCH

(*b*) National Oceanic and Atmospheric Administration Sea Grant Program; U.S. Army Corps of Engineers Coastal Engineering Research Center.
(*c*) Bruce H. Adee, Assoc. Professor.
(*d*) Includes experimental, theoretical and field data.
(*e*) To increase our knowledge of the effectiveness of floating breakwaters and develop predictive models for design.
(*g*) Computer programs for prediction of the transmission performance, motions and mooring line focus have been developed. These have been verified through wave-tank experiments and the results obtained in the field.
(*h*) **Theoretical Analysis of Floating Breakwater Performance,** B. Adee, W. Martin, *1974 Floating Breakwater Conf. Papers, Univ. of Rhode Island Marine Tech. Rept. Series No. 24*, Newport, R.I., pp. 21-40, 23-25 Apr. 1974.
Prototype Performance Characteristics of a Floating Breakwater, D. Christensen, E. Richey, *1974 Floating Breakwater Conf. Papers, Univ. Rhode Island Marine Tech. Rept. Series No. 24*, Newport, R.I., pp. 159-180, 23-25 Apr. 1974.
Floating Breakwaters–State of the Art, E. Richey, R. Nece, *1974 Floating Breakwater Conf. Papers, Univ. Rhode Island Marine Tech. Rept. Series No. 24*, Newport, R.I., pp. 1-20, 23-25 Apr. 1974.
Analysis of Floating Breakwater Performance, B. Adee, *Symp. Modeling Techniques, 2nd Ann. Symp. Waterways Harbors and Coastal Engrg. Div., ASCE*, San Francisco, Calif., pp. 1585-1602, 3-5 Sept. 1975.
Floating Breakwaters: An Idea Whose Time Has Returned, B. Adee, *Ocean 75*, San Diego, Calif., pp. 707-715, 22-25 Sept. 1975.
Analysis of Floating Breakwater Mooring Forces, B. Adee, *Ocean Engineering Mechanics*, presented *Winter Ann. Mtg. ASME*, Houston, Tex., pp. 77-92, 30 Nov.-5 Dec. 1975.
A Review of Developments and Problems in Using Floating Breakwaters, B. Adee, *Offshore Tech. Conf. Proc. II*, Houston, Tex., pp. 225-236, 3-6 May 1976.
Prototype Performance Characteristics of Two Floating Breakwaters, D. Christensen, E. Richey, *Offshore Tech. Conf. Proc. II*, Houston, Tex., pp. 225-236, 3-6 May 1976.
Floating Breakwater Performance, B. Adee, *15th Conf. Coastal Engrg.*, Honolulu, Hawaii, 11-17 July 1976.
Floating Breakwater Field Assessment Program, Friday Harbor, Washington, B. Adee, E. Richey, D. Christensen, *U.S. Army, Corps of Engineers, Coastal Engrg. Research Center, Tech. Paper No. 76-17*, Oct. 1976.
Operational Experience with Floating Breakwaters, B. Adee, *Pacific Nortwest Section, Soc. Naval Architects and Marine Engrs.*, Jan. 1977.

WEBB INSTITUTE OF NAVAL ARCHITECTURE, Crescent Beach Road, Glen Cove, N. Y. 11542. Dr. Edward V. Lewis, Director of Research.

169-08398-520-48

STUDIES OF HIGH FREQUENCY SHIP HULL RESPONSE TO WAVES ("Springing")

(*b*) U.S. Coast Guard.
(*d*) Experimental (model) and theoretical; applied research.
(*e*) Tests with a jointed model, having variable natural frequency of vertical two-noded vibration, in regular waves in a model basin. Magnitude of the vertical bending moment excited at different encounter frequencies, particularly at and near resonance, are measured. Theoretical computer calculations were made and results compared with experiments.
(*f*) Completed.
(*g*) Excellent results have been obtained in tests at various speeds in short waves. Calculations give good agreement in certain cases, but more extensive experimental and theoretical work is needed.
(*h*) **Feasibility Study of Springing Model Tests of a Great Lakes Bulk Carrier,** D. Hoffman, R. W. van Hooff, *Intl. Shipbuilding Progress*, Mar. 1973.
Experimental and Theoretical Evaluation of Springing on a Great Lakes Bulk Carrier, D. Hoffman, R. W. van Hooff, *D.O.T., USCG Rept. CG-D-8-74*, July 1973. *Intl. Shipbuilding Progress*, June 1976.

169-09216-420-21

ANALYSIS OF OCEAN WAVE SPECTRA FOR APPLICATION TO SHIP DESIGN

(*b*) U.S. Navy, General Hydromechanics Research Program, Naval Ship Research and Development Center.
(*c*) Dr. Dan Hoffman.
(*d*) Theoretical; applied research.
(*e*) Analyzing wave spectra from various ocean weather ships and comparing trends of wave and weather parameters. Developing "families" of spectra of different levels of severity for use in ship design and comparing these with various ideal formulations. Purpose is to provide more reliable ocean wave data and show how they can best be applied in design.
(*f*) Completed.
(*g*) Significant trends established, differing from generally-used ideal formulations.
(*h*) **Analysis of Measured and Calculated Spectra,** D. Hoffman, *Proc. Intl. Symp. Dynamics of Marine Vehicles and Structures in Waves*, Univ. College, London, Apr. 1974.
Analysis of Wave Records and Application to Design, D. Hoffman, *Proc. Intl. Symp. Ocean Wave Measurement and Analysis*, New Orleans, Sept. 1974.
Wave Data Application for Ship Response Predictions, D. Hoffman, *Final Report to Naval Sea Systems Command*, Oct. 1975.

169-09217-520-45

IMPROVED AUTOMATIC STEERING OF SHIPS

(*b*) National Maritime Research Center (Maritime Administration), Kings Point, N. Y.
(*d*) Experimental; applied research.
(*e*) A model of a fast container ship is arranged for automatic steering in following waves in a towing basin. A PDP-8

minicomputer in the control loop permits changes in the control equations and constants to be made for experimental evaluation. Purpose is to improve quality of steering control in rough seas for modern high-speed ships.

(*f*) Completed.

(*g*) Tests demonstrated feasibility of digital control method of evaluating a control system. For one particular model conclusions were reached regarding optimum choice of coefficients in control equation.

(*h*) **A Model Steering Study,** Femenia, Lewis, van Hooff, Zubaly. Report issued by National Maritime Research Center, Kings Point, N. Y.

Ship Model Evaluation of Automatic Control Systems, R. van Hooff, *4th Control Systems Symp.*, The Netherlands, Oct. 1975.

Model Steering Tests with Digital Control, R. van Hooff, E. V. Lewis, *NMRC Rept. NMRC-KP-169*, Oct. 1976.

169-10343-520-45

EVALUATION OF HEAVY WEATHER DAMAGE AVOIDANCE SYSTEM

(*b*) National Maritime Research Center (Maritime Administration), Kings Point, N.Y.

(*c*) Dr. Dan Hoffman.

(*d*) Shipboard investigation; applied research.

(*e*) Evaluating effectiveness of an Edo/MarAd System for giving warning of high accelerations, high stresses or shipping of water and predicting effect of course and speed changes. Numerous instrumented voyages on S.S. *Lash Italia* are being monitored and data analyzed.

(*g*) System is proving to be very effective when ship officers become familiar with its use.

(*h*) **Heavy Weather Damage Avoidance System on the S.S. Lash Italia,** D. Hoffman, *Preliminary Report*, Dec. 1976 (to be published by NMRC).

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WESTERN WASHINGTON STATE COLLEGE, Department of Geography and Regional Planning, Bellingham, Wash. 98225. Dr. Thomas A. Terich.

171-10403-410-61

THE EFFECTS OF WOOD DEBRIS AND DRIFT LOGS ON ESTUARINE BEACHES OF NORTHERN PUGET SOUND

(*b*) State of Washington Water Research Center, Washington State University.

(*d*) Field investigation, applied research.

(*e*) Large volumes of wood debris and logs are washed from forested slopes and clear cut sites into Pacific Northwest streams and rivers. Their concentrations often significantly alter stream physiography and flow. Similar effects may be found along the shore-lines of Puget Sound, the ultimate depository for much river-borne debris. This study is designed to investigate the effects wood debris have on beach sediment erosion and deposition. Thirty beach sites over two-hundred mile of shoreline are being monitored to determine seasonal movements and volumetric changes of deposited drift logs. Additionally, a time lapse camera is used to detect short term movements of drift logs under various tides and wave conditions.

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WEST VIRGINIA UNIVERSITY, Department of Mechanical Engineering and Mechanics, Morgantown, W. Va. 26506. Dr. E. F. Byars, Department Chairman.

172-10016-700-54

PULSATILE FLOW THROUGH AN ORIFICE

(*b*) National Science Foundation.

(*c*) R. A. Bajura.

(*d*) Experimental and theoretical; basic research; M.S. and Ph.D. theses.

(*e*) The flow and pressure fields in the neighborhood of a standard flow metering orifice are being studied experimentally to determine the details of the flow field in both steady and pulsatile flow conditions. Weigh tank calibrations of water flow rates through the orifice under pulsatile flow are performed for the purpose of determining the flow metering error. An analytical model of the flow through the orifice is being developed for flow metering purposes.

(*h*) **Studies of Pulsating Incompressible Flow Through Orifice Meters,** R. A. Bajura, M. T. Pellegrin, *Proc. Natl. Bureau of Standards Flow Measurement Symp., Gaithersburg, Md., Feb. 1977, NBS SP484* (Sept. 1977).

172-10017-060-33

INFLUENCE OF PUMPED STORAGE FLOWS ON THERMAL STRATIFICATION IN RESERVOIRS

(*b*) Office of Water Research and Technology.

(*c*) R. A. Bajura and S. H. Schwartz.

(*d*) Experimental.

(*e*) Determine procedures for distortion modeling of pumped storage reservoir systems and determine the influence of the discharge and withdrawal cycles on thermal stratification and mixing.

172-10018-210-75

FLOW DISTRIBUTION IN MANIFOLDS

(*b*) Babcock & Wilcox Company.

(*c*) R. A. Bajura.

(*d*) Experimental and analytical; M.S. thesis.

(*e*) The distribution of flow into the lateral branches of typical manifold systems is studied experimentally to obtain characteristic pressure loss coefficients for the system. These coefficients are employed in an analytical model for predicting the flow distribution in manifolds systems.

(*h*) **Flow Distribution Manifolds,** R. A. Bajura, E. H. Jones, *J. Fluids Engrg., ASME* **98,** 4, Dec. 1976.

172-10019-210-60

PULVERIZED COAL TRANSPORT MANIFOLD DESIGN STUDY

(*b*) State of West Virginia.

(*c*) R. A. Bajura.

(*d*) Theoretical.

(*e*) Determine design methods for the prediction of flow distribution in manifold systems transporting pulverized coal in water slurries or air/coal suspensions.

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UNIVERSITY OF WISCONSIN-MADISON, Department of Civil and Environmental Engineering, Madison, Wis. 53706. Professor T. Green.

173-10026-220-50

VERTICAL TRANSPORT OF SEDIMENT DUE TO FINGERING PROCESSES

(*b*) NASA.

(*d*) Experimental, field work; basic research; Masters thesis.

(*e*) Sediment fingering, analogous to "salt fingering" in the ocean, may govern the vertical transport of muddy surface water associated with spring run-off. The process is being quantified in the laboratory, and looked for in the field.

(*g*) See (h) below.

(*h*) **Suspension Fingers,** Houk and Green, *Deep-Sea Research* **20,** pp. 757-761, 1973.

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UNIVERSITY OF WISCONSIN-MADISON, Department of Geology and Geophysics, Madison, Wis. 53706. Mary P. Anderson, Asst. Professor.

174-09870-820-33

GROUNDWATER-LAKE INTERACTION

(*b*) Office of Water Research and Technology, U.S. Dept. of the Interior.
(*d*) Field and theoretical, applied; M.S. thesis.
(*e*) Investigate the importance of groundwater in the water budget of seepage lakes. A representative lake in northwest Wisconsin has been instrumented. Field data will provide input to a model of the groundwater flow system in the vicinity of the lake.

174-09871-820-36

HEAT TRANSPORT IN GROUNDWATER

(*b*) EPA.
(*d*) Field and theoretical; applied and development; Ph.D. thesis.
(*e*) Seepage of heated water from a cooling lake and movement of the heat through the groundwater system are being monitored at a site in south central Wisconsin. Field data will provide input for a mathematical model.

174-09872-820-36

GROUNDWATER-SURFACE WATER RELATIONSHIPS IN THE MENOMONEE RIVER BASIN

(*b*) EPA in cooperation with the International Joint Commission.
(*d*) Field, applied; M.S. thesis.
(*e*) Groundwater conditions adjacent to the Menomonee River in southeast Wisconsin are being studied with regard to groundwater flow and water quality. Purpose is to assess the nature and amount of pollutants transported to the Menomonee River by groundwater.

UNIVERSITY OF WISCONSIN-MADISON, Marine Studies Center, 1225 W. Dayton Street, Madison, Wis. 53706.

175-10028-420-44

WAVE DECAY DUE TO BUOYANCY-DRIVEN TURBULENCE

(*b*) NOAA (Sea Grant).
(*c*) Professor T. Green.
(*d*) Experimental, theoretical; basic research; Doctoral thesis.
(*e*) Long wave decay is studied in the presence of high-Rayleigh-number convective turbulence. The decay rate is correlated with a bulk Rayleigh number, and interpreted in terms of a convectively induced Reynolds stress. Long, standing wave interaction is studied using the method of multiple time scales. The theoretical results are corroborated with experimentally obtained energy transfer rates.
(*f*) Suspended.
(*g*) See (e) and (h).
(*h*) **Long-Wave Decay Due to Convective Turbulence,** Green and Kang, *J. Fluid Mechanics* **73,** pp. 427-444, 1976.

175-10029-440-54

STUDIES OF THE KEWEENAW CURRENT IN LAKE SUPERIOR

(*b*) National Science Foundation.
(*c*) Professor T. Green.
(*d*) Field (and some theoretical) work; basic research; Masters, Doctoral theses.
(*e*) The strong Keweenaw Current along the north shore of the Keweenaw Peninsula in Lake Superior is measured using hydrography, moored current meters, and aerial techniques. Particular attention is paid to surface kinetic energy transfer (obtained mainly with airborne photogrammetry), and upwelling events (using hydrography and airborne thermal scanning).
(*f*) Data analysis ongoing.
(*g*) See (h).
(*h*) **Short-Period Variations in a Great Lakes Coastal Current by Aerial Photogrammetry,** Yeske and Green, *J. Physcial Oceanography* **5,** 1, pp. 125-135, 1975.
Horizontal Turbulent Energy Transfer Associated with a Great Lakes Coastal Current, Green and Yeske, *Tellus* **27,** pp. 384-396, 1975.
Coastal Upwelling/Downwelling Cycles in Southern Lake Superior, Niebauer, Green, Ragotzkie, *J. Physical Oceanography* (in press).

175-10030-870-60

POWER PLANT THERMAL PLUMES IN LAKE MICHIGAN

(*b*) Wisconsin Department of Natural Resources; Wisconsin power companies.
(*c*) Professor T. Green.
(*d*) Field work; applied research.
(*e*) All significant thermal plumes along the Wisconsin Shore of Lake Michigan were scanned with an airborne thermal scanner approximately weekly for over a year. Surface areas within various isotherms were calculated.
(*f*) Completed.
(*g*) Reports with all data have been given to the funding agencies. See also (h).
(*h*) **Types of Thermal Plumes in Coastal Waters,** Green, Madding, and Scarpace, *Water Research* **11,** pp. 123-127, 1977.
Thermal Plumes Along the Wisconsin Shore of Lake Michigan, Madding, Scarpace, and Green, *Trans. Wisc. Academy of Sciences* (in press).

175-10031-470-44

ELECTROMAGNETIC MEASUREMENTS OF HARBOR FLUSHING

(*b*) NOAA (Sea Grant).
(*c*) Professor T. Green.
(*d*) Field, laboratory, theoretical; basic, applied research; Doctoral thesis.
(*e*) Electromagnetic potentials associated with flowing water are used to estimate channel flow, and harbor flushing.

175-10032-870-33

HIGH-FREQUENCY TEMPERATURE FLUCTUATIONS IN THERMAL PLUMES

(*b*) OWRT, Sea Grant.
(*c*) Professor T. Green.
(*d*) Field work; basic research; Masters thesis.
(*e*) Temperature fluctuations have been measured at seven points in the vertical in a power-plant thermal plume. The results are being interpreted in terms of boundary-layer entrainment mechanisms.
(*f*) Suspended.

175-10033-440-44

CURRENT MEASUREMENTS IN THE LAKE MICHIGAN COASTAL ZONE

(*b*) Great Lakes Environmental Research Laboratory (NOAA).
(*c*) Professor T. Green.
(*d*) Field work; basic research; Doctoral thesis.
(*e*) Thirteen current meters were moored in the coastal zone of south-eastern Lake Michigan in the spring and summer of 1976. The data will be processed to measure coherence and phase propagation along the shore.

175-10034-330-10

FLOW IN THE KEWEENAW WATERWAY, IN LAKE SUPERIOR

(*b*) U.S. Army Corps of Engineers.

(*c*) Professor R. A. Ragotzkie.
(*d*) Field work; applied research; Doctoral thesis.
(*e*) Flow in the Keweenaw Waterway is related to forcing by runoff, by Lake Superior water-level variations, and by atmospheric pressure variations.

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UNIVERSITY OF WISCONSIN-MADISON, Department of Mathematics, Madison, Wis. 53706. Professor Peter E. Ney, Department Chairman.

176-08400-420-61

WATER WAVES IN LAKES AND OCEANS

(*b*) National Science Foundation.
(*c*) Professors R. E. Meyer and M. C. Shen.
(*d*) Theoretical; basic and applied research.
(*e*) Physical oceanography research.
(*h*) **Planetary Waves over the Rotating Earth,** M. C. Shen, *Phys. Fluids* **18,** p. 1225, 1975.
Gradual Reflection of Short Waves, R. E. Meyer, *SIAM J. Appl. Math.* **29,** pp. 481-492, 1975.
Uniform Asymptotic Approximation for Viscous Fluid Flows Down An Inclined Plane, M. C. Shen, S. M. Shih, *SIAM J. Math. Anal.* **6,** pp. 560-581, 1975.
Leakage and Response of Waves Trapped by Round Islands, R. E. Meyer, C. Lozano, *Phys. Fluids* **19,** pp. 1075-1088, 1976.

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UNIVERSITY OF WISCONSIN—MADISON, Department of Meteorology, Madison, Wis. 53706. Professor T. Green.

177-10027-460-33

SURFACE MIXING DUE TO RAIN

(*b*) OWRT.
(*d*) Experimental, field; basic, applied research; Doctoral thesis.
(*e*) Warm rain mixes cool, fresh receiving surface water downward to distances up to a meter. The same phenomenon occurs when rain falls into salt water. This mixing is measured as a function of time, raindrop size, rain temperature, and intensity.
(*f*) Completed.
(*g*) See (h).
(*h*) **A Note on Surface Waves Due to Rain,** D. Houk, T. Green, *J. Geophys. Res.* **81,** 24, Aug. 20, 1976.
Surface Mixing Due to Rain, T. Green, D. Houk, *J. Fluid Mechanics* (in press).

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WOODS HOLE OCEANOGRAPHIC INSTITUTION, Woods Hole, Mass. 02543. Dr. Paul M. Fye, Director.

178-07786-450-20

DYNAMIC PROCESSES IN THE DEEP SEA

(*b*) Office of Naval Research; National Science Foundation.
(*c*) Dr. W. S. Schmitz, Jr., and Dr. N. P. Fofonoff.
(*d*) Field investigations.
(*e*) Time series observations in the deep ocean support theoretical work on the nature of dynamic processes in the sea. Several experiments are usually in progress simultaneously.
(*g*) Several recent experiments have yielded the following information: (1) data from an array of current meters in the deep Gulf Stream recirculation region suggests that this recirculation is driven by the oceanic eddy field; (2) Gulf Stream rings have been identified as possible sources for enhanced fine-structure activity near Bermuda through the generation of internal waves by eddy interaction with the island slope and subsequent mixing by the internal wave field; (3) a new current was found near 4,000 in depth along the western foot of the Bermuda Rise.
(*h*) **On the Deep Circulation in the Western North Atlantic,** W. J. Schmitz, Jr., *J. Mar. Res.* (in press).

178-09224-440-44

COASTAL CIRCULATION IN THE GREAT LAKES

(*b*) NOAA, Great Lakes Environmental Research Laboratory.
(*c*) Dr. Gabriel T. Csanady.
(*d*) Analysis of field data, theoretical work.
(*e*) Data collected during the International Field Year on the Great Lakes are analyzed and interpreted in terms of the concepts of fluid mechanics.
(*g*) Concentrated bands of relatively fast currents are produced by storms near the shore of large lakes within what is now known as the "coastal boundary layer." The physical properties of the coastal currents depend not only on the size and shape of the lake basin, but also significantly on the density distribution of the water and the rotation of the earth.
(*h*) **Hydrodynamics of Large Lakes,** G. T. Csanady, *Ann. Review Fluid Mechanics* **7,** pp. 357-383, 1975.
Circulation, Diffusion and Frontal Dynamics in the Coastal Zone, G. T. Csanady, *J. Great Lakes Res.* **1,** 1, pp. 18-32, Oct. 1975.
Topographic Waves in Lake Ontario, G. T. Csanady, *J. Physical Oceanog.*, pp. 93-103, 1975.
Mean Circulation in Shallow Seas, G. T. Csanady, *J. Geophys. Res.* **81,** 30, pp. 5389-5399, 1976.
The Coastal Jet Conceptual Model in the Dynamics of Shallow Seas, G. T. Csanady, *The Sea* **6,** pp. 117-144, 1977.
Intermittent "Full" Upwelling in Lake Ontario, G. T. Csanady, *J. Geophys. Res.* **82,** 3, pp. 397-419, 1977.

178-09225-450-52

COASTAL BOUNDARY LAYER TRANSECT

(*b*) Brookhaven National Laboratory; Energy Research and Development Administration.
(*c*) Dr. Gabriel T. Csanady.
(*d*) Theoretical and field investigations.
(*e*) Current, temperature and salinity measurements in the coastal zone (0-12 km from shore) south of Long Island are used to elucidate flow structure in the coastal boundary layer.
(*g*) The transient and the long-term circulation over continental shelves is determined by impulses received from winds and tides as well as by the density distribution of the water. An important part of the transient shelf-wide flow pattern is the coastal boundary layer where storms produce concentrated bands of currents. Time-averaged flow is, by contrast, controlled by density variations consequent upon fresh water runoff near shore.
(*h*) **Lateral Momentum Flux in Boundary Currents,** G. T. Csanady, *J. Physical Oceanography* **5,** 4, pp. 705-717, 1975.
Wind-Driven and Thermohaline Circulation Over the Continental Shelves, G. T. Csanady, *Effects of Energy Related Activities on the Atlantic Continental Shelf, Session II* (Characteristic Physical Processes of the Atlantic Continental Shelf; Chairman, G. T. Csanady), pp. 31-46.
Nearshore Currents off Long Island, J. T. Scott, G. T. Csanady, *J. Geophys. Res.* **81,** 30, pp. 5401-5409, 1976.

178-09226-450-20

OCEANIC VARIABILITY AND DYNAMICS

(*b*) Office of Naval Research.
(*c*) Dr. Thomas B. Sanford.
(*d*) Theoretical and field investigations.
(*e*) Most of the effort concentrates on the measurement and interpretation of motionally induced electric fields arising with water moving through the geomagnetic field. Theoretical studies and field observations are combined to define the spatial and temporal structure of flow in shallow channels and in the deep ocean.

(*g*) A better understanding of the physics of induction in broad shallow channels has been achieved. This understanding allows, under certain circumstances, the transport of a stream to be electrically monitored. In the deep ocean measurements of electric current profiles have revealed new data on the vertical structure of horizontal currents. Much of the depth-dependent variability is contributed by inertial currents.

(*h*) **A Velocity Profiler Based on Acoustic Doppler Principles,** R. G. Drever, T. B. Sanford, *WHOI Ref. No. 76-96*, 36 pages, 1976 (unpublished manuscript).

Vertical Energy Propagation of Inertial Waves: A Vector Spectral Analysis of Velocity Profiles, K. D. Leaman, B. Sanford, *J. Geophysical Research* **80,** 15, pp. 1975-1978, 1975.

A Study of Velocity Profiles Through the Main Thermocline, H. T. Rossby, T. B. Sanford, *J. Physical Oceanography* **6,** 5, pp. 766-774, 1976.

Observations of the Vertical Structure of Internal Waves, T. B. Sanford, *J. Geophysical Research* **80,** 27, pp. 3861-3871, 1975.

Volume Transport Measurements on a Salt Marsh Drainage Channel Using Geomagnetic Induction, T. B. Sanford, *Limnology and Oceanography* (in press).

A Velocity Profiler Based on the Principles of Geomagnetic Induction, T. B. Sanford, R. G. Drever, H. Dunlap, *Deep Sea Research* (in press).

178-09227-450-20

BENTHIC BOUNDARY LAYER STRUCTURE IN THE VEMA CHANNEL

(*b*) National Science Foundation, Oceanography Section.
(*c*) Dr. David A. Johnson.
(*d*) Field investigation.
(*e*) New data from closely spaced hydrocasts, thermograd profiles, vertical nephelometer profiles, and direct bottom current observations in the Vema Channel (southwest Atlantic Ocean) allow an interpretation of the flow regime and the structure of the benthic boundary layer.
(*f*) Completed.
(*g*) The data are consistent with a model of an asymmetrical flow regime wherein strongest northward current velocities are adjacent to the western wall of the channel; frictional effects due to the presence of the wall induce strong turbulence in the flow; turbulent mixing results in a "blurring" of the benthic thermocline and a slight elevation of near-bottom temperatures in the channel axis; and upslope advection in a bottom boundary Ekman layer results in a veering of the mean velocity vector and the transport of coldest water upslope to the eastern margin of the channel.
(*h*) **Abyssal Hydrography, Nephelometry, Currents, and Benthic Boundary Layer Structure in the Vema Channel,** *J. Geophys. Res.* **81,** pp. 5771-5786, 1976.

WORCESTER POLYTECHNIC INSTITUTE, Alden Research Laboratories, Holden, Mass. 01520. Professor George E. Hecker, Director, Research Laboratories.

179-06509-870-73

INDIAN POINT NUCLEAR GENERATING STATION

(*b*) Consolidated Edison Company of New York.
(*d*) Experimental applied research.
(*e*) Hydraulic model studies were conducted to reduce the environmental effects of the discharge of condenser circulating water into the Hudson River by design of the outfall structures and to demonstrate compliance to pertinent New York State thermal discharge criteria. Two models were required: A 1 to 75 uniform scale model simulating the near-field temperature rise patterns where initial discharge momentum governed flow phenomena, and distorted scale model, 1 to 400 horizontal and 1 to 80 vertical scales, simulating far-field temperature rise patterns where temperature induced buoyance and surface heat transfer were governing phenomena. The far-field model simulated time varying tidal stage and velocity and included cumulative temperature effects.
(*f*) Project completed–report on file.
(*g*) Temperature patterns were determined at hourly intervals during the tidal cycle for various outfall geometries, plant operating conditions, and freshwater runoff flow rates. Specific model tests were conducted to simulate field conditions occurring during the field surveys. Model results were then compared to field survey data to demonstrate the usefulness and limitations of physical modeling techniques as applied to an estuary.
(*h*) **Hydrothermal Model Studies of Existing Shoreline Outfall and Offshore Diffusers for Indian Point Units 1 through 3,** J. B. Nystrom, G. E. Hecker, *ARL Rept. No. 61-74/M118CF.*

179-10416-340-73

NORTH ANNA POWER STATION–CONDENSER INLET TUNNEL

(*b*) Virginia Electric and Power Company, Richmond, Virginia.
(*d*) Experimental, for design.
(*e*) The operating efficiencies of steam turbines will be affected by the distribution of cooling water flow among condensers. A hydraulic model constructed to a scale ratio of 1:14 was used to determine flow distribution, flow patterns, and head losses for the North Anna condenser inlet tunnel design and flow patterns within the condenser waterboxes.
(*f*) Tests completed.
(*g*) The flow rate through any individual condenser line was within -1.5% and +2% of the average flow rate through all six condenser lines. At all condenser inlet riser locations, the flow patterns within the waterbox were dominated by the waterbox geometry and were relatively unaffected by the intake area geometry.
(*h*) **Hydraulic Model Test of Condenser Inlet Tunnel, North Anna Units 3 and 4,** P. A. March, *ARL Rept. No. 60-77/M250BF.*

179-10417-340-73

SEABROOK STATION–DISCHARGE STRUCTURES

(*b*) Yankee Atomic Electric Company, Westborough, Massachusetts.
(*d*) Experimental, for design.
(*e*) Knowledge of the head losses associated with discharge structures during normal operation and backflushing operation is important for sizing the pumps in the circulating water system, calculating normal plant circulating water flow and temperature rise, and predicting backflushing transients. Information on the velocity distribution in the discharge jets is required to determine whether or not the assumptions in previous analytical models and the operating conditions in the hydrothermal model are adequately satisfied. Models of proposed designs for the bifurcated discharge structures, constructed to a scale ratio of 1:11, were used to determine velocity distribution in the discharge jets and loss coefficients for operation in the discharging mode and backflushing mode. An analytical investigation was also conducted to determine the potential for flow-induced vibrations in the proposed guard bars.
(*f*) Tests completed.
(*g*) The original discharge structure design produced swirling, unstable discharge jets. The discharge loss coefficient (based on the velocity head in the discharge riser) for this design was 2.4, and the backflushing loss coefficient (also based on the velocity head in the discharge riser) was 1.3. The recommended discharge structure design produced stable, well-defined discharge jets which were relatively uniform in velocity. The discharging loss coefficient for the recommended design was 2.0, and the backflushing loss coefficient was 0.7. The analytical investigation in-

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dicated the potential for flow-induced guard bar vibrations during normal discharging operation with the proposed guard bar design.

(*h*) **Experimental Study of Discharge Structures–Seabrook Station**, P. A. March, P. J. Smith, *ARL Rept. No. 130-76/M296CF*, Nov. 1976.

179-10418-340-73

SEABROOK STATION–INTAKE STRUCTURES

(*b*) Yankee Atomic Electric Company, Westborough, Massachusetts.
(*d*) Experimental, for design and evaluation.
(*e*) Knowledge of the head losses associated with intake structures during normal operation and backflushing operation is important for sizing the pumps in the circulating water system, calculating normal plant circulating water flow and temperature rise, and predicting backflushing transients. Information on the flow patterns and velocities in the vicinity of the intake structures is required to help evaluate the potential for entrainment of marine organisms. Sectional models constructed to a scale ratio of 1:35 were used to determine vertical flow patterns and velocities in the vicinity of individual intake structures. An overall model constructed to the same scale was used to determine loss coefficients and to determine horizontal flow patterns in the vicinity of an array of three intake structures.
(*f*) Tests completed.
(*g*) The velocity profiles at the upstream face of the recommended intake design were relatively uniform and generally less than 1 ft/sec for ambient currents of 0, 0.2, and 0.4 kt. Downstream velocity profiles were skewed for ambient currents of 0.2 and 0.4 kt, and the maximum measured velocity was 1.3 ft/sec. For all of the ambient currents tested, each intake appeared to operate independently from the other intakes. Each intake's range of influence was limited horizontally to about one intake diameter on either side of the intake periphery for an ambient current of 0.2 kt and to about one-half intake diameter to either side for an ambient current of 0.4 kt. For the recommended intake design, the average intaking loss coefficient (based on the velocity head in the intake riser) was 0.35 and the average backflushing loss coefficient (also based on the velocity head in the intake riser) was 1.04.
(*h*) **Experimental Study of Intake Structures, Seabrook Station**, P. A. March, R. G. Nyquist, *ARL Rept. No. 131-76/M296DF*, Nov. 1976.

179-10419-390-70

BIRD MACHINE COMPANY–SPRAY COOLING TESTS

(*b*) Bird Machine Company, S. Walpole, Massachusetts.
(*d*) Experimental, for design.
(*e*) Spray cooling equipment is typically evaluated from thermal performance tests for single units, and the results of single unit tests are then used to predict the performance of an array of spray cooling units. Thermal performance of five experimental spray cooling nozzles was evaluated on the basis of cooling efficiency (degrees of cooling divided by ambient temperature minus wet bulb temperature), NTU (number of transfer units), and power factor (the ratio between the rate of heat transfer from the sprayed water and the pumping power required for the unit).
(*f*) Tests completed.
(*g*) When tested under identical conditions, the cooling efficiency values and NTU values for one of the experimental nozzles averaged about 2.0 times as high as corresponding values obtained for a standard spray unit using a conical deflector, and power factor values averaged about 1.7 times as high.
(*h*) Draft report completed, final report available soon.

179-10420-340-73

SALEM NUCLEAR GENERATING STATION–CONDENSER INLET WATERBOX

(*b*) Public Service Electric and Gas Company, Newark, New Jersey.
(*d*) Experimental, for design.
(*e*) A high content of abrasive silt in the circulating water increases the potential for rapid condenser tube erosion. If the inlet waterbox design produces regions of high velocity within the waterbox, this could result in accelerated erosion, as well as decreased condenser efficiencies and increased losses. A hydraulic model, constructed to a geometric scale ratio of 1:10, was used to determine flow patterns, velocity distribution, and losses within an inlet waterbox. The potential for erosive wear was evaluated on the basis of particle impingement angles and velocities. Using this criterion, the original design and a variety of revisions were investigated in the model.
(*f*) Tests completed.
(*g*) A revision which included a vaned inlet elbow and an open grid of rectangular bars in the inlet waterbox reduced the potential for erosive wear by producing a more uniform velocity distribution at the tubesheet. No significant increase in inlet area losses was measured for this revision.
(*h*) **Hydraulic Model Study of Condenser Inlet Waterbox**, P. A. March, *ARL Rept. No. 25-77/M302BF*, Jan. 1977.

179-10421-710-20

INVESTIGATION OF SCHLIEREN SYSTEM FOR DETERMINING PRESSURE FIELDS

(*b*) Office of Naval Research, Washington, D.C.
(*d*) Basic research.
(*e*) A high-velocity water tunnel was constructed, and experiments were conducted to determine the utility of the Schlieren flow visualization technique for quantitative measurement of the pressure distribution around projectiles during water entry.
(*f*) Tests completed.
(*g*) Qualitative and quantitative evaluation of Schlieren photographs revealed no trends which could be related to pressure gradients around the test objects for approach velocities up to the maximum obtainable value of 100 ft/sec. Sensitivity tests indicated a minimum observable pressure gradient of 3,700 psi/inch, which would require an approach velocity of over 500 ft/sec.
(*h*) **Investigation of Schlieren System for Determining Pressure Fields**, P. A. March, *ARL Rept. No. 26-77/M6387F*, Jan. 1977.

179-10422-350-73

TURNERS FALLS FISH PASSAGE

(*b*) Northeast Utilities Service Company, Hartford, Connecticut.
(*d*) Experimental for design.
(*e*) Two hydraulic models were constructed of two portions of a fish ladder to be constructed on the Connecticut River at the Turners Falls dam. The ladders will provide upstream passage for migrating shad and Atlantic salmon. A 1/16 model included a portion of the dam with its control gates and the river immediately downstream where the fish ladder entrance was located. The objective of the model was to locate the entrance in a velocity zone that would be acceptable to the migrating fish. The second model was 1/9 scale and included vertical slotted weirs for the migrating fish. The slotted weirs had to operate under a wide range of head and tailwater levels. The objective of the model was to determine if the slotted weirs produced equal head loss over the range of flows.
(*f*) Tests completed.
(*g*) The entrance to the fish ladder was optimized so that a favorable velocity distribution was produced in the river in the approach to the entrance. For the 1/9 model, testing showed that an additional weir was necessary to reduce the drop per weir so that velocities through the slots would be lower.

(*h*) **Model Studies of the Proposed Turners Falls Fish Passage Facilities**, B. J. Pennino, G. E. Hecker, *ARL Rept. No. 73-75/M295F.*

179-10423-340-73

NEW HAVEN HARBOR STATION–SWIRLING FLOW STUDY

(*b*) United Illuminating Company, New Haven, Connecticut.
(*d*) Experimental, applied research.
(*e*) Asymmetrical velocity distribution and increased swirl due to upstream piping bends contributed to excessive impeller erosion in a main boiler feedwater pump. A full scale model, operating at a Reynolds number of 2.3×10^6, was used to investigate axial and tangential (swirl) velocity distributions for the original piping configuration and several modified configurations.
(*f*) Tests completed, report in progress.
(*g*) A uniform axial velocity distribution was provided and swirl was eliminated by a configuration which included a splitter plate, a multiply-vaned upstream elbow, and an increased length of straight pipe immediately upstream from the inlet.
(*h*) Final report available soon.

179-10424-340-73

CHARLESTOWN NUCLEAR STATION DIFFUSER

(*b*) New England Power Company, Westborough, Massachusetts.
(*d*) Experimental and analytical.
(*e*) A 1/90 scale model of a portion of the coastline near Charlestown, Rhode Island was constructed in which various staged diffuser designs were tested at a prototype depth of 30 ft. The model is 150 ft long by 75 ft wide and built in wood on an elevated platform to minimize bottom heat loss. Surface and vertical structure of the plume are measured by 370 thermistor in transient cross flow conditions. Temperature distributions resulting from transient backflushing operations are also to be tested. An analytical model will be used for the intermediate field plume predictions.
(*f*) Tests in progress.
(*g*) A final diffuser configuration was established meeting imposed discharge criteria. Near-field thermal characteristics are being compared with existing mathematical models for staged diffusers in shallow water.

179-10425-340-73

HOPE CREEK BLOWDOWN

(*b*) Public Service Electric & Gas Company, Newark, New Jersey.
(*d*) Analytical.
(*e*) The cooling tower blowdown of the Hope Creek Generating Station will be discharged in the Delaware River through a single pipe. The net concentration of the discharge is larger than ambient and the discharge is, therefore, negatively buoyant. A mathematical model was developed for the prediction of the plume characteristics including the following regions: Buoyant round jet, bottom impingement region, bottom flow away plume. Various discharge designs will be tested.

179-10426-170-00

FIELD MEASUREMENT OF AIR WATER INTERFACIAL HEAT TRANSFER

(*b*) Experimental basic research for Master's thesis.
(*e*) Purpose of the study is to develop a method to directly measure the net heat transfer from a water surface to the atmosphere to compare the experimental results to results predicted from existing prediction formulations and to develop new prediction techniques which perform better under various meteorologic conditions. The experimental method developed utilizes an energy budget method for two control volumes in a 1200 acre lake to determine net heat transfer rate and to separate the effects of water surface temperature dependent mechanisms from those which are independent.
(*g*) Existing prediction formulations have been shown to underestimate evaporative conductive heat losses by from 15-30 percent on the average.

179-10427-340-75

PARAMETRIC EVALUATION OF THE HYDRAULIC PERFORMANCE OF A CIRCULATING WATER SCREENWELL

(*b*) Offshore Power Systems, Jacksonville, Florida.
(*d*) Experimental applied research.
(*e*) A 9.6 to 1 hydraulic model was constructed of a single bay of the circulating water intake structure for the proposed floating nuclear power plant. Flow patterns within the pump bay were evaluated with respect to smooth and efficient pump operation for various strengths of flow parallel to the face of the bay and for various traveling screen locations. Flow withdrawal of adjacent bays were simulated to determine the effect of operation of adjacent bays on flow patterns within the pump bay. Abnormal flow disturbances such as vortex formation were of particular interest.
(*f*) Project completed–report on file.
(*g*) Velocity distributions in back of the bar screen at the entrance to the pump bay and in front of the pump bellmouth are shown as functions of current parallel to bar screen and traveling screen location. Flow patterns beneath the bellmouth are also presented. The effect of operation of adjacent bays on velocity distribution is also shown.
(*h*) **Parametric Evaluation of the Hydraulic Performance of a Circulating Water Screenwell**, J. B. Nystrom, *ARL Rept. 55-77/M353F.*

179-10428-340-75

CAYUGA GENERATING STATION

(*b*) United Engineers & Constructors, Inc., Boston, Massachusetts.
(*d*) Experimental applied research for design.
(*e*) A 100 to 1 scale model of a section of Lake Cayuga was used to develop a diffuser outfall for the proposed Cayuga Station condenser circulating water which would meet applicable New York State thermal discharge criteria. A field study of the thermal plume from a nearby existing power station was conducted to verify the model operation. The interaction of the existing plant with various proposed outfall structures was determined for various conditions of ambient temperature, current speed and water surface elevation. Four diffuser alternatives and two surface discharge alternatives were evaluated.
(*f*) Project completed–report on file.
(*g*) Steady state surface temperature patterns were determined as well as selected vertical profiles for various water surface elevations, ambient temperatures, and lake current speeds. Results using tee, angled tee, and staged diffusers, as well as two surface discharges, were compared to determine the optimum configuration based on site constraints such as maximum and minimum diffuser submergence, circulating water temperature rise, and the interaction with the existing station.
(*h*) **Hydrothermal Model Studies of Diffuser Alternatives for the Cayuga Station Site**, J. B. Nystrom, *ARL Rept. No. 73-76/M252B.*

179-10429-340-73

MITCHELL NUCLEAR POWER STATION

(*b*) American Electric Power, New York, New York.
(*d*) Experimental for design.
(*e*) A 1/10 model of a cooling tower pump intake and screenwell area was constructed to test for vortices in an existing station.
(*f*) Study completed.
(*g*) Vortices occurred in the model and they were eliminated by a sloping plate extending from the surface to the soffit of the horizontal pump intake.

(*h*) Report in progress.

179-10430-340-75

PERRY NUCLEAR STATION

(*b*) Gilbert Associates, Inc., Reading, Pennsylvania.
(*d*) Experimental for design.
(*e*) Two models are being constructed to determine flow patterns in a cooling tower basin and the effect of these flow patterns on vortices at the circulating water pumps. A 1/64 overall basin model will determine flow patterns to impose on a 1/16 local model of the pump intakes. Any vortices at the pump intakes are to be observed and modifications to be recommended to remove the vortices and improve the flow patterns. The strength of vorticity is to be measured by a vortimeter in the pump column and fluctuating pressures are to measure and correlate with vortices.
(*f*) Study to be completed in summer 1977.

179-10431-360-73

PIT 6 SPILLWAY

(*b*) Pacific Gas and Electric Company, San Francisco, California.
(*d*) Experimental for design.
(*e*) A 1/40 hydraulic model was constructed of the Pit 6 dam with its spillway gates, stilling basin, and river immediately downstream. The stilling basin has experienced floor block failure and severe erosion due to cavitation. The objective of the study was to modify the stilling basin so that energy dissipation was accomplished with more stable floor blocks.
(*f*) Testing essentially completed.
(*g*) Testing showed that more stable streamlined floor blocks could produce the same energy dissipation as the original design. The streamlining would reduce the cavitation damage. Wall heights in the dissipator were increased and horizontal and lateral forces were measured on the floor blocks.
(*h*) Report in progress.

179-10432-340-73

BAD CREEK PUMPED STORAGE PROJECT

(*b*) Duke Power Company, Charlotte, North Carolina.
(*d*) Experimental for design.
(*e*) A 1/58 model of the upper reservoir and radial flow intake structure was constructed. The purpose of the study is to test for vortices in the generating mode and modify the structure so that velocities and head losses are minimized in both modes. Forces on the roof are to be determined.
(*f*) Study to be completed summer 1977.

179-10433-870-75

SHOCKOE CREEK COMBINED SEWER DIVERSION STRUCTURES

(*b*) Hayes, Seay, Mattern and Mattern, Roanoke, Va.
(*d*) Experimental for design.
(*e*) A 1/18 nondistorted model was constructed of two interconnected sewers located in Richmond, Virginia. Diversion structures will be constructed in these sewers to bypass combined storm runoff to a treatment plant where it will be stored for treatment. The objective of the study was to minimize the increase in sewer water levels due to the newly constructed diversion structures.
(*f*) Tests completed.
(*g*) The diversion structures were streamlined to minimize the pressures in upstream sewers. The diversion tunnels were streamlined and designed for maximum capacity.
(*h*) **Model Tests of the Shockoe Creek Combined Sewer Diversion Structures,** B. J. Pennino, D. K. White, G. E. Hecker, *ARL Rept. No. 127-76/M307F.*

179-10434-350-73

HYCO LAKE CHUTE SPILLWAY

(*b*) Carolina Power and Light Company, Raleigh, North Carolina.
(*d*) Experimental for design.
(*e*) A 1/26 hydraulic model was constructed of an existing curved chute spillway whose floor had been damaged during a large flow.
(*f*) Tests completed.
(*g*) Testing showed that the floor had been damaged due to uplift caused by a hydraulic jump that moved up and down the chute due to the noncontrolled tailwater. Flow patterns on the chute were nonuniform because of the curve and flow had overflowed on one wall where scour occurred. A drop structure was designed that contained the supercritical flow. The spillway was rated and a tailwater operation plan was developed.

179-10435-340-73

FAIRFIELD PUMPED STORAGE PROJECT

(*b*) South Carolina Electric and Gas Company, Columbia, South Carolina.
(*d*) Experimental for design.
(*e*) A 1/70 nondistorted hydraulic model of the upper reservoir intake structure and portions of the reservoir. The studies involved the optimizing of the intake structure to minimize vortices, head losses and velocities at the trash racks. A diffuser was designed and tested so that minimum velocities were obtained in the pumping mode. The effect of mixing in the reservoir and selective withdrawal was investigated.
(*f*) Tests completed.
(*g*) A diffuser reduced reservoir mixing during pumping and a skimmer wall for generation was shown to be ineffective. Peak pumping velocities at the trash racks were reduced from 21 ft/sec to 11 ft/sec.
(*h*) **Hydraulics and Thermal Model Study for the Fairfield Pumped Storage Intake Structure,** B. J. Pennino, A. G. Ferron, *ARL Rept. No. 63-75/M260A.*

179-10436-340-75

HYDRODYNAMICS OF VORTEX SUPPRESSION IN THE REACTOR BUILDING SUMP

(*b*) Burns and Roe, Inc., and General Public Utilities.
(*d*) Experimental.
(*e*) To establish the outflow characteristics of the reactor sump for the decay heat removal system, a hydraulic model of the reactor sump and surrounding area was fabricated to the geometric scale of 3:1. The main purpose of the study was to verify that the reactor sump would properly drain the emergency cooling water without the development of free surface vortices or other flow irregularities which might adversely influence the operation of the decay heat removal system. In the event that undesirable flow conditions occurred, means of improving flow patterns were to be developed.
(*f*) Completed.
(*g*) Tests showed that the original design could be improved with respect to free surface vortices. Considering the prototype operating conditions and possible scale effects on modeling vortices, it seemed desirable to improve the flow characteristics. Various changes to the screens were made, and grids were installed over the sump to attenuate flow rotation. Tests at increased model flow rate and water temperatures were conducted to investigate possible scale effects on vortices, and the resulting data indicated that the recommended prototype installation will operate satisfactorily.
(*h*) **Hydrodynamics of Vortex Suppression in the Reactor Building Sump Decay Heat Removal System,** W. W. Durgin, L. C. Neale, R. L. Churchill, *ARL Rept. No. 46-77/M202FF*, Feb. 1977.

179-10437-710-00

VELOCITY-AREA METHODS OF MEASURING ASYMMETRIC FLOWS IN RECTANGULAR DUCTS

(*d*) Experimental, theoretical, basic research, Master's thesis.
(*e*) Several commonly used velocity-area methods of flow rate determination are being investigated to establish sensitivity to velocity and locational errors as well as disturbed velocity profiles. Comparisons are being made with data obtained in square ducts using a flow calibration facility.

179-10438-240-00

FLOW INDUCED VIBRATION

(*d*) Experimental, theoretical, basic research, Master's thesis.
(*e*) Syncronization of vortex shedding with the elastic modes of a structure are being studied using a vertical wind tunnel. Particular attention is directed towards characterizing the fluid mechanic forces acting on a cylinder and the nature of the "locking on" process.
(*h*) **The Interaction of Elastically Mounted Cylinders with Secondary Vortex Streets,** J. Stasaitis, *M.S. Thesis*, Worcester Polytechnic Institute, July 1976.

UNIVERSITY OF WYOMING, College of Engineering, Department of Mechanical Engineering, University Station, Box 3295, Laramie, Wyo. 82071. Dr. Don L. Boyer.

181-09267-020-00

DIFFUSION AND LAGRANGIAN STATISTICS IN TURBULENT FLOWS

(*b*) National Center for Atmospheric Research, which is sponsored by the National Science Foundation, computer support.
(*c*) W. R. Lindberg.
(*d*) Theoretical; numerical.
(*e*) Research in both single particle and relative dispersion in turbulent flows. Effects of spectral structure, inertia and gravity are being investigated for homogeneous flows.
(*h*) **A Simulation of Turbulent Dispersion and Lagrangian Statistics,** W. R. Lindberg, *Proc. 6th Canadian Cong. Appl. Mech.*, pp. 665-6 (1977).

181-09268-060-00

TURBULENCE IN STABLY STRATIFIED FLOWS

(*b*) Office of Naval Research.
(*c*) W. R. Lindberg.
(*d*) Experimental; theoretical.
(*e*) Turbulent structure of a stably stratified wake flow at moderate Reynolds numbers. Simultaneous measurements of u, w and ρ are analyzed to determine the spatial and spectral characteristics of the turbulent wake. Additionally, a stratified, turbulent Ekman layer is being investigated experimentally.

PROJECT REPORTS FROM U.S. GOVERNMENT LABORATORIES

U.S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE

NORTH CENTRAL REGION, 2000 West Pioneer Parkway, Peoria, Ill. 61614. E. R. Glover, Deputy Administrator.

300-0185W-810-00

PREDICTING RUNOFF AND STREAMFLOW FROM LOESS AND CLAYPAN WATERSHEDS IN MISSOURI AND IOWA

See Water Resources Research Catalog **9**, 2.0671.

300-0186W-220-00

RATES AND PROCESSES OF RESERVOIR SEDIMENTATION IN THE CORN BELT

See Water Resources Research Catalog **9**, 2.0670.

300-0188W-810-00

SEDIMENT YIELDS FROM AGRICULTURAL WATERSHEDS IN THE CORN BELT

See Water Resources Research Catalog **9**, 2.0672.

300-0189W-810-00

MANAGEMENT PRACTICES FOR CONTROL OF RUNOFF, EROSION, AND TILTH-CLAYPAN SOILS

See Water Resources Research Catalog **9**, 4.0133.

300-0192W-810-00

THE MOVEMENT AND YIELD OF NUTRIENTS FROM AGRICULTURAL WATERSHEDS

See Water Resources Research Catalog **9**, 5.0934.

300-0342W-860-00

RELATION OF AGRICULTURAL PRACTICES TO WATER QUALITY IN THE NORTH APPALACHIAN REGION

See Water Resources Research Catalog **9**, 2.0818.

300-0344W-860-00

RELATION OF AGRICULTURAL PRACTICES AND NATURAL VEGETATION TO NUTRIENT CONTENT OF WATERS

See Water Resources Research Catalog **9**, 5.0903.

300-0346W-830-00

WATER EROSION PROCESSES IN RELATION TO WINDS IN THE GREAT PLAINS

See Water Resources Research Catalog **9**, 2.0545.

300-0347W-870-00

USE OF SEWAGE SLUDGE ON AGRICULTURAL LANDS

See Water Resources Research Catalog **9**, 5.0910.

300-0433W-820-00

EFFECT OF SOIL AND WATER MANAGEMENT PRACTICES ON WATER AND NUTRIENT MOVEMENT AND STORAGE IN THE SOIL

See Water Resources Research Catalog **11**, 3.0100.

300-0434W-810-00

CORNBELT WATERSHED SEDIMENT LOSSES

See Water Resources Research Catalog **11**, 2.0381.

300-0435W-820-00

WATER CONSERVATION FOR NORTHERN PLAINS SOILS

See Water Resources Research Catalog **11**, 3.0109.

300-0436W-810-00

HYDROLOGY AND WATER QUALITY OF WATERSHEDS SUBJECTED TO SURFACE MINING

See Water Resources Research Catalog **11**, 4.0138.

300-01723-350-00

HYDRAULICS OF WATER CONTROL STRUCTURES AND CHANNELS

See St. Anthony Falls Hydraulic Lab. Project Nos. 00111, 01168, 07677, and 08993.

(*b*) Cooperative with the Minnesota Agric. Expmt. Station; and the St. Anthony Falls Hydraulic Laboratory.

(*c*) Mr. Fred W. Blaisdell, Research Leader, St. Anthony Falls Hydraulic Lab., 3rd Ave. S. E. at Mississippi River, Minneapolis, Minn. 55414.

(*d*) Experimental; applied research for development and design.

(*e*) Research dealing with the design, construction, and testing of structures for conserving and controlling soil and water are carried out. Cooperation with and coordination of the tests at the Stillwater, Oklahoma, Water Conservation Structures Laboratory is maintained. Model tests of the Marsh Creek Dam principal spillway, Contra Costa County, California, have been completed. Present research is a generalized investigation of the scour at cantilevered pipe outlets. The objective is to develop criteria for the design of plunge pool energy dissipators for any pipe size, discharge, and bed material.

(*h*) The following reports and papers are in various stages of completion: **Hydraulics of Closed Conduit Spillways, Part XIII. The Hood Drop Inlet; Part XIV. Antivortex Walls for Drop Inlets; Part XV. Low-Stage Inlet for the Two-Way Drop Inlet; Part XVI. Elbows and Transitions for the Two-Way Drop Inlet; Part XVII. The Two-Way Drop Inlet with a Semicylindrical Bottom.**

Hydraulic Model Investigation of Marsh Creek Dam Principal Spillway, Contra Costa County, California; Theory of Flow in Long Siphons; The Hood Inlet Self-Regulating Siphon Spillway; The Two-Way Drop Inlet Self-Regulating Siphon Spillway.

300-04275-830-00

MECHANICS AND CONTROL OF EROSION BY WATER

(*b*) Cooperative with Purdue University Agricultural Expmt. Station.

(*c*) W. C. Moldenhauer, Agronomy Dept., Life Science Bldg., Purdue Univ., Lafayette, Ind. 47907.
(*d*) Experimental, theoretical, and field investigations; basic, applied and developmental research.
(*e*) Field, laboratory, and analytical studies of soil detachment and transport by rainfall and runoff; effects of plant covers, crop residues, tillage methods, and soil treatments on erosion and runoff; hydraulics of eroding runoff and rainfall; and mathematical models of the soil erosion process as a basis for improved methods of erosion prediction and erosion control.
(*g*) A mathematical model was developed for deposition of noncohesive sediment on concave slopes by steady overland flow. The model successfully described the spatial and temporal variation of the deposited material and sediment yield. An applied sediment transport equation was developed that can be used in conjunction with the Universal Soil Loss Equation (USLE) to estimate sediment yield from farm fields and construction sites. The influence of flow rate on rill erosion and the stability of surface mulches was studied. Basic, mathematical erosion analysis indicated how the slope length exponent of the USLE varies with slope length, soil erodibility, steepness, and runoff. Delineation of interrill and rill erosion and the physical characteristics of eroded particles from the two processes were studied in the field under simulated rainfall. Recent user's manuals were prepared on using the USLE in the development of plans to control agricultural pollution. The main guideline manual, USDA-Agriculture Handbook 282, for the USLE is also currently being revised.
(*h*) **Mathematical Simulation of Upland Erosion by Fundamental Erosion Mechanics,** G. R. Foster, L. D. Meyer. In: *Present and Prospective Technology for Predicting Sediment Yield and Sources, ARS-S-40,* Agric. Research Service, USDA, Washington, D.C., pp. 190-207, 1975.
The Influence of Vegetation and Vegetative Mulches on Soil Erosion, L. D. Meyer, G. R. Foster, S. Niklov, *Trans. ASAE* **18,** 5, pp. 905-911, 1975.
Source of Soil Eroded by Water from Upland Slopes, L. D. Meyer, G. R. Foster, M. J. M. Romkens. In: *Present and Prospective Technology for Predicting Sediment Yield and Sources, ARS-S-40,* Agric. Research Service, USDA, Washington, D.C., pp. 177-189, 1975.
Erosion Modeling on a Watershed, C. A. Onstad, G. R. Foster, *Trans. ASAE* **18,** 2, pp. 288-292, 1975.
Control of Water Pollution from Cropland–Volume I and II, A Manual for Guideline Development, B. A. Stewart, D. A. Woolhiser, W. H. Wischmeier, J. H. Caro, M. H. Frere, *ARS-H-51,* Agric. Research Service, USDA, Washington, D.C., 111 pages, 1975.
Estimating the Soil Loss Equation's Cover and Management Factor for Undisturbed Areas, W. H. Wischmeier. In: *Present and Prospective Technology for Predicting Sediment Yield and Sources, ARS-S-40,* Agric. Research Service, USDA, Washington, D.C., pp. 118-124, 1975.
Use and Misuses of the Universal Soil-Loss Equation, W. H. Wischmeier, *J. Soil and Water Conservation* **31,** 1, pp. 5-9, 1976.

300-09272-810-00

PREDICTING RUNOFF AND STREAMFLOW FROM AGRICULTURAL WATERSHEDS IN THE NORTH APPALACHIAN REGION

(*b*) Cooperative with the Ohio Agricultural Research and Development Center, Wooster, Ohio 44691.
(*c*) W. R. Hamon, Location/Research Leader, USDA-ARS North Appalachian Experimental Watershed, Coshocton, Ohio 43812.
(*d*) Experimental, theoretical, and field investigations; basic and applied research.
(*e*) Watershed studies to describe infiltration, percolation, groundwater, and overland and channel flow components of the hydrologic cycle with a mathematical model and to relate these components to definable physical parameters; predict watershed flow, including transport of water, sediment and agricultural chemicals and wastes; describe areal precipitation characteristics; and relate ET losses to soil, vegetation, and meteorological factors.
(*g*) Rainfall caught by national gages, on the average, was 96.6 percent of that measured by a pit gage in a WMO international comparison of raingauges in 15 countries. Runoff volumes for 10- and 25-year design storms were predicted for an unpaved cattle barnlot using the most probable antecedent soil moisture. A numerical model was developed for solving axisymmetric infiltration problems. The USDAHL Watershed Model was used to assess the hydrologic effects of land-use change and was found sufficiently accurate to establish the statistical significance of such changes.
(*h*) **Comparisons of Measured and Estimated Daily Potential Evapotranspiration in a Humid Region,** L. H. Parmele, J. L. McGuinness, *J. Hydrol.* **22,** pp. 239-251, 1974.
Preliminary Report on Measurements of Precipitation Intercomparisons Between Pit Gauge and National Gauges, L. Schiff, F. R. Dreibelbis, *Intl. Conf. Results of the Intl. Hydro. Decade and On Future Programmes in Hydro. (ENDEC/Doc. 7-Appendix 2),* Versailles, France, Sept. 1974.
A Watershed Soils Index of Runoff Potential, J. L. McGuinness, W. M. Edwards, *J. Soil & Water Conservation* **30,** July-Aug. 1975.
Estimating Quantity and Quality of Runoff from Eastern Beef Barnlots, W. M. Edwards, J. L. McGuinness, *Proc. 3rd Intl. Symp. Livestock Wastes, ASAE,* Champaign, Ill., pp. 408-411, Apr. 1975.
Use of Axisymmetric Infiltration Model and Field Data to Determine Hydraulic Properties of Soils, R. W. Jeppson, R. W. Rawls, W. R. Hamon, D. L. Schrieber, *Water Resources Res.* **11,** 2, Feb. 1975.
Using a Mathematical Model to Assess the Hydrological Effects of Land-Use Change, K. J. Langford, J. L. McGuinness, *ARS-NC-31,* pp. 1-38, June 1976.
Runoff Sampling: Coshocton Vane Proportional Sampler, W. M. Edwards, H. E. Frank, T. E. King, D. R. Gallwitz, *ARS-NC-50,* Nov. 1976.
A Comparison of Modeling and Statistical Evaluation of Hydrologic Change, K. J. Langford, J. L. McGuinness, *Water Resources Research* **12,** 6, pp. 1322-1324, Dec. 1976.

300-09273-870-00

FIELD DETERMINATION OF NUTRIENTS AND SEDIMENTS FROM NON-POINT SOURCES

(*b*) Cooperative with the Minnesota Agricultural Experiment Station, St. Paul, Minn. 55108.
(*c*) R. A. Young and C. A. Onstad, Agric. Engineers, North Central Soil Conservation Research Center, Morris, Minn. 56267.
(*d*) Experimental, theoretical, and field investigations; basic and applied research.
(*e*) Assess the impact of man on nutrient enrichment of lakes and streams. Develop hydrologic and nutrient budget for agricultural and non-agricultural watersheds. Relate water quality and sediment yield to watershed land use practices. Model agricultural chemical transport.
(*g*) Agricultural and non-agricultural non-urban watersheds in west central and northern Minnesota were instrumented. Data collection began in 1974. Data are being used to test agricultural chemical transport models, develop water and nutrient budgets for the watersheds, and to relate water quality and sediment yields to land use practices.

300-10561-220-00

PREDICTING EROSION AND SEDIMENT YIELDS FROM AGRICULTURAL WATERSHEDS

(*b*) Cooperative with Minnesota Agricultural Experiment Station, St. Paul, Minn. 55108.

(*c*) C. A. Onstad and R. A. Young, Agricultural Engineers, North Central Soil Conservation Research Center, Morris, Minn. 56267.
(*d*) Experimental, theoretical, and field investigations, basic and applied research.
(*e*) Models have been developed to estimate erosion and sediment yield from ungaged agricultural basins. Simulation timeframes range from single storms to average annual amounts. Spatial distribution of sediment sources within the basin are also predicted. Plot experiments, indoor and outdoor, are being conducted to provide quantification of sediment characteristics deemed pertinent for the transport of agricultural chemicals. Data are also being collected from agricultural basins to relate water quality and sediment yield to land use practices.
(*g*) Sediment yield models incorporating hydrologic and hydraulic flow properties have been designed for single storms and annual amounts. Validation tests have begun and comparisons with results from other models have been conducted with favorable results. A method has also been developed and tested to determine the particle size distribution of eroded soil based on original soil matrix properties.
(*h*) **Watershed Erosion Model Validation for Southwest Iowa,** C. A. Onstad, R. F. Piest, K. E. Saxton, *Proc. 3rd Federal Inter-Agency Sedimentation Conf.*, pp. 1-22 to 1-34, 1976.
Prediction of Particle Size Composition of Eroded Soil, R. A. Young, C. A. Onstad, *Trans. ASAE* **19,** 6, pp. 1071-1075, 1976.
Basin Sediment Yield Modeling Using Hydrological Variables, C. A. Onstad, A. J. Bowie, *Proc. Intl. Symp. Erosion and Solid Matter Transport in Inland Rivers*, Paris, France, July 4-8, 1977.
A Sediment Yield Model for Large Watersheds, C. A. Onstad, A. J. Bowie, C. K. Mutchler, *Paper No. 76-2536, ASAE Winter Mtg.*, Chicago, Ill. Dec. 14-17, 1976.

U.S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE

NORTHEASTERN REGION, Room 333, B-003, Agricultural Research Center, West Beltsville, Md. 20705. Dr. S. C. King, Deputy Administrator.

301-0440W-870-00

CONTROL OR PREVENTION OF SOIL AND WATER POLLUTION FROM FERTILIZERS

See Water Resources Research Catalog **11,** 5.1355.

301-08432-810-00

PREDICTING RUNOFF AND STREAMFLOW FROM AGRICULTURAL WATERSHEDS IN THE NORTHEAST

(*b*) Cooperative with the Vermont Agric. Expmt. Sta., New Hampshire Agric. Expmt. Sta., and NOAA.
(*c*) Ronald Z. Whipkey, Research Leader, 150 Kennedy Drive, South Burlington, Vt. 05401.
(*d*) Experimental and field observations–applied and operational research.
(*e*) Hydrologically characterize important physiographic areas of the northeast, to study the effects of land use in local watershed hydrology and on downstream water supply and water quality. Specific research includes runoff processes (surface and subsurface) kinematics of overland flow, water input to watersheds from spring melt of northern snowpack, and hydrologic characteristics of watersheds as they affect water storage, transmission, drainage, and water availability for crop growth.
(*g*) A runoff model developed for Pennsylvania uplands aids in determining maximum areas of the watershed that contribute storm runoff as well as changes of contributing area depending on time and storm characteristics. Shallow water equations were tested on a major watershed stream and kinematic and dynamic wave motions studied; physical factors of importance in flood routing through natural channels were determined from this. Water input to watersheds arising from snowmelt is greatly affected by slope-aspect-cover and elevation in the physiographical complex watersheds of northern New England.

301-09276-810-00

PREDICTING THE QUANTITY AND QUALITY OF RUNOFF AND STREAMFLOW FROM AGRICULTURAL WATERSHEDS IN THE NORTHEAST

(*b*) Cooperative with The Pennsylvania State University Agricultural Experiment Station.
(*c*) Dr. Harry B. Pionke, Soil Scientist, Northeast Watershed Research Center, 111 Research Building A, University Park, Pa. 16802.
(*d*) Experimental and field investigation; applied research, development.
(*e*) The hydrologic, geologic properties and water quality of selected watersheds are being investigated. The purpose is to develop concepts and then to develop and test predictive models of water, sediment and chemicals origin and transport on a watershed basis.
(*g*) A storm hydrograph model based on the partial contributing area concept was developed that utilizes a physically based infiltration capacity for computation of rainfall excess and two stages of kinematic routing. Predictions of four storm hydrographs from a single watershed using this model closely approximated the observed hydrographs.
A method for selecting initial soil moisture for simulation of storm hydrographs was developed, tested and found to be highly correlated with observed data. The method assumes soil moisture values can be represented by normal probability distributions. A number of techniques for estimating daily potential evapotranspiration were evaluated. Based on lysimeter data, methods utilizing measured net or solar radiation were superior to techniques which did not utilize this input. A modified combination equation developed at Coshocton, Ohio, appeared to have considerable potential for estimating actual daily ET in the humid northeastern United States.
A snowmelt and water input model has been developed and partially tested on New England data. The model requires, as input, 10 day meteorological data and, as output provides snowmelt delivered to the ground surface at selected points over a watershed.
Seasonal variations of soluble phosphate output (PO_4-P) from an agricultural Pennsylvanian watershed ranged from an average of 20-30 ppb in winter. Concentration in base flows averaged about 10 ppb, and were relatively constant. A simulation of partial area hydrologic contribution predicted the phosphate concentration from washoff of riparian lands to contain upwards of 100 ppb.
(*h*) **Partial Area Hydrology and Its Application to Water Resources,** E. T. Engman, *Water Resour. Bull. 10*, 3, pp. 512-521, 1974.
A Partial Area Model for Storm Flow Synthesis, E. T. Engman, A. S. Rogowski, *Water Resour. Res. 10*, pp. 464-472, 1974.
Soluble Phosphate Output of an Agricultural Watershed in Pennsylvania, W. J. Gburek, W. R. Heald, *Water Resour. Res.* **10,** pp. 113-118, 1974.
Comparisons of Measured and Estimated Daily Potential Evapotranspiration in a Humid Region, L. H. Parmele, J. L. McGuinness, *J. Hydrol.* **22,** pp. 239-251, 1974.
Transient Response of a Layered, Sloping Soil to Natural Rainfall in the Presence of a Shallow Water Table: Experimental Results, A. S. Rogowski, E. T. Engman, J. L. Jacoby, Jr., U.S. Dept. of Agric., *ARS-NE-30*, 61 pages, 1974.
Seasonal Snow Accumulation, Melt and Water Input–A New England Model, R. L. Hendrick, R. J. DeAngelis, *J. Appl. Meteor.* **15,** pp. 717-727, 1976.

Predictability of Effects of a Severe Local Storm in Pennsylvania, W. J. Gburek, R. L. Hendrick, A. S. Rogowski, M. L. Paul, *J. Appl. Meteor.* **16**, 2, pp. 136-144, 1977.
Other publications available on request.

301-10622-810-00

PREDICTING THE EFFECTS OF LAND USE AND MANAGEMENT ON RUNOFF AND WATER YIELD

(*b*) Cooperative with Howard University, Washington, D.C., and the University of Maryland, College Park, Maryland.
(*c*) Dr. E. T. Engman, Chief, Hydrograph Laboratory, Plant Physiology Institute, Northeastern Region, ARS-SWAS, Beltsville, Md. 20705.
(*d*) Basic and applied research.
(*e*) The mission of the USDA-ARS Hydrograph Laboratory is to conduct research on methodology for predicting and evaluating water yield from large areas in the United States and to work directly with the USDA Soil Conservation Service and other action agencies in the development and transfer of current research results for their immediate use. The Hydrograph Laboratory functions as a national laboratory by extending and modifying the research results from local and regional studies to broader geographical areas. Research emphasis is placed on determining the effects of land use, climate variability and hydrologic variability on water yield from large areas. An interdisciplinary approach to the problem is being used and relies heavily on mathematical modeling, sensitivity analysis and remote sensing.
(*g*) A digital model of watershed hydrology was developed for application to areas limited in size only by representation of aerial rainfall by a single raingage. Satisfactory applications have exceeded one-hundred square miles. The model is unique in that it uses linear dimensions readily available by surface or remote sensing surveys to compute volumes for storage including soil porosity, surface depressions, and contour furrows. Rates such as infiltration, surface runoff, and drainage outflow as well as groundwater recharge are then computed as exhaustion phenomenon with the rate diminishing as storage is depleted. Watersheds are zoned by similarity of most important storages (i.e. soil porosity for infiltration, or if overland flow is more important, topography would be used for zoning). Each zone is then used as a unit for hydrologic computations to derive inflow to the channel from experienced rainfall. The influences of vegetation and tillage practices are readily discernable. Plant characteristics and growth indexes are used to compute the effects of land use and treatment in modification of soil porosity. Copies of the model and computer program have been requested by a great number of action agencies and educational institutions, both foreign and domestic.
A model was developed for routing high-velocity flood flows in the main channel separately from the low-velocity flows on the floodplain. This removes the necessity for using average velocities since the uneven water surface derived from separate routings is now used to compute lateral attenuation between the main stem and the floodplains. This procedure is particularly useful in computing the energies for sediment transport, particularly in the main channel and for using the differences in energies to determine depositions on the floodplain. The model is still in the testing stage and is in process of application to actual cases in cooperation with action agencies. Both models are available in digital form either on tape or punched cards and can be obtained at no cost.
(*h*) The Hydrograph Laboratory maintains current bibliographies and abstracts of papers published since the inception of the Laboratory in 1961. These are available upon request at no cost.

U.S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE

SOUTHERN REGION, P.O. Box 53326, New Orleans, La. 70153. Dr. A. W. Cooper, Deputy Administrator.

302-0203W-830-00

SEDIMENT YIELD IN RELATION TO WATERSHED FEATURES IN THE SOUTHERN PLAINS

See Water Resources Research Catalog **6**, 2.1175.

302-0205W-810-00

HYDROLOGIC PERFORMANCE OF AGRICULTURAL LANDS IN THE SOUTHERN PLAINS

See Water Resources Research Catalog **6**, 2.1177 and 2.1180.

302-0206W-810-00

PRECIPITATION PATTERNS ON UPSTREAM WATERSHEDS IN THE SOUTHERN PLAINS

See Water Resources Research Catalog **6**, 2.1179.

302-0207W-810-00

STREAMFLOW REGIMES OF AGRICULTURAL WATERSHEDS IN THE SOUTHERN PLAINS

See Water Resources Research Catalog **6**, 2.1181.

302-0208W-810-00

RUNOFF AND STREAMFLOW REGIMES OF AGRICULTURAL WATERSHEDS IN THE WESTERN GULF REGION

See Water Resources Research Catalog **6**, 2.1366.

302-0209W-810-00

SEDIMENT YIELD IN RELATION TO WATERSHED FEATURES IN THE WESTERN GULF-REGION

See Water Resources Research Catalog **6**, 2.1367.

302-0210W-830-00

WATER EROSION CONTROL PRACTICES FOR THE TEXAS BLACKLAND PRAIRIE

See Water Resources Research Catalog **6**, 2.1377.

302-0213W-810-00

PRECIPITATION PATTERNS ON UPSTREAM WATERSHEDS IN THE WESTERN GULF REGION

See Water Resources Research Catalog **6**, 2.1368.

302-0214W-810-00

HYDROLOGIC PERFORMANCE OF AGRICULTURAL LANDS IN THE WESTERN GULF REGION

See Water Resources Research Catalog **6**, 2.1369.

302-0215W-810-00

PREDICTING RUNOFF AND STREAMFLOW FROM AGRICULTURAL WATERSHEDS IN THE WESTERN GULF REGION

See Water Resources Research Catalog **6**, 2.1376.

302-0216W-830-00

SEDIMENT YIELD IN RELATION TO WATERSHED AND CLIMATIC CHARACTERISTICS IN THE WESTERN GULF REGION

See Water Resources Research Catalog **6**, 2.1379.

302-0444W-810-00

PREDICTING RUNOFF AND STREAMFLOW FROM AGRICULTURAL WATERSHEDS IN THE SOUTHEAST

See Water Resources Research Catalog **11**, 2.0139 and 2.0141.

302-0445W-220-00

SEDIMENT DEPOSITION

See Water Resources Research Catalog **11**, 2.0379.

302-0446W-220-00

SOURCE AND MAGNITUDE OF SEDIMENT YIELD FROM WATERSHEDS

See Water Resources Research Catalog **11**, 2.0380.

302-0447W-300-00

STREAM CHANNEL STABILITY AND STABILIZATION PRACTICES

See Water Resources Research Catalog **11**, 4.0170.

302-0448W-810-00

MODELING OF SOIL MOISTURE AND EVAPOTRANSPIRATION ON UNIT SOURCE WATERSHEDS

See Water Resources Research Catalog **11**, 2.0052.

302-0449W-810-00

PREDICTION OF GROUNDWATER CONTRIBUTIONS TO RUNOFF FROM AGRICULTURAL WATERSHEDS

See Water Resources Research Catalog **11**, 2.0053.

302-0450W-860-00

INVESTIGATION OF EVAPORATION AND EVAPOTRANSPIRATION LOSSES FROM RESERVOIRS

See Water Resources Research Catalog **11**, 2.0111.

302-0451W-810-00

RAINFALL-RUNOFF RELATIONSHIP FROM UNIT SOURCE WATERSHEDS

See Water Resources Research Catalog **11**, 2.0164.

302-0452W-860-00

ONSITE WATER CONSUMPTION AT FLOODWATER RETARDING STRUCTURES

See Water Resources Research Catalog **11**, 3.0020.

302-0453W-810-00

EFFECT OF FLOODWATER RETARDING STRUCTURES ON RUNOFF IN THE SOUTHERN PLAINS

See Water Resources Research Catalog **11**, 4.0033.

302-0454W-870-00

TRANSPORT AND LOSS OF WATER-BORNE POLLUTANTS FROM AGRICULTURAL WATERSHEDS

See Water Resources Research Catalog **11**, 5.0405.

302-0455W-810-00

MODELING SURFACE RUNOFF FROM COMPLEX WATERSHEDS

See Water Resources Research Catalog **11**, 2.0173.

302-0456W-810-00

MODELING HYDROLOGIC PROCESSES ON AGRICULTURAL WATERSHEDS IN WESTERN GULF REGION

See Water Resources Research Catalog **11**, 2.0064.

302-7002-390-00

DEVELOPMENT OF CONSERVATION STRUCTURES AND WATERFLOW MEASURING DEVICES

See U.S. Department of Agriculture, Agricultural Research Service, North Central Region, Project 01723.

(*b*) Cooperative with the Oklahoma Agric. Exp. Station, Oklahoma State University, Stillwater, Oklahoma.

(*c*) Dr. W. R. Gwinn, Research Leader, Water Conservation Structures Laboratory, P.O. Box 551, Stillwater, Okla. 74074.

(*d*) Experimental, applied research for development and design.

(*e*) The laboratory conducts hydraulic research to (1) develop structures for the conveyance, storage, and disposal of surplus runoff water; (2) develop stream flow devices needed to monitor stream flow quantity and quality; (3) develop basic knowledge of the hydraulics of surface flows and determine the ability of vegetation and/or various manufactured materials to protect constructed water conveying channels from eroding and releasing sediments to the stream below. (Also listed in Water Resources Research Catalog 9, 7.0314. See also U.S. Department of Agriculture, Agricultural Research Service, North Central Region, Project 300-01723-350-00.)

(*g*) A stepped baffle trash rack on closed conduit spillways for floodwater retarding reservoirs has been tested with models and prototype size structures. A berm installation with riprap approach is currently under study. A structural low-drop spillway using a baffle to dissipate energy and control grade in channels is currently under study using a movable-bed basin. A drop-box entrance for H and HL flumes was developed for use in water quality flow measurement. A hydraulic jump is formed on a sloping floor upstream of the flume to provide mixing and suspension of particles. New research is beginning on a mathematical model of the removal of soil from the surface of a large soil mass by flowing water using geology and soil characteristics as parameters. Physical evaluation of the model will be made in the laboratory and field.

(*h*) **Estimating Annual Water Yield from Oklahoma Watersheds for Drought Periods**, W. R. Gwinn. Presented *Industrial Waste and Advanced Water Conf.*, Apr. 1973.

Model Study of Supercritical Flow Channel Transition for Nichols Creek, Kenedy, Tex., W. O. Ree, D. K. McCool, U.S. Dept. of Agric., *ARS-S-11*, 28 pages, July 1973.

Hydraulic Model Studies of Little River Gaging Station B, W. R. Gwinn, U.S. Dept. of Agric., *ARS-S-38*, 32 pages, June 1974.

A Laboratory Evaluation of Trash Racks for Drop Inlets, W. R. Gwinn, G. G. Hebaus, *USDA Technical Bulletin 1506*, 70 pages, Sept. 1975.

Dependable Yield of Reservoirs with Intermittent Inflows, W. R. Gwinn, W. O. Ree, *ASAE Trans.* **18**, 6, pp. 1085-1088, 1975.

Discharge Equations for Hs, H, and HL Flumes, W. R. Gwinn, D. A. Parsons, *J. Hydr. Div., ASCE* **102**, HY1, pp. 73-88, Jan. 1976.

Stepped Baffled Trash Rack for Drop Inlets, W. R. Gwinn, *ASAE Trans.* **19**, 1, pp. 97-104 and 107, 1976.

Emergency Spillway Performance at Site 39, Upper Black Bear Creek Watershed, Oklahoma, W. O. Ree, U.S. Dept. of Agric., *ARS-S-109*, 6 pages, Mar. 1976.

Emergency Spillway Performance, Upper Red Rock Creek Watershed, Oklahoma, W. O. Ree, U.S. Dept. of Agric., *ARS-S-108*, 18 pages, May 1976.

Comparison of Chute and Stilling Basin Performance for Three Different Drop Box Inlets, W. O. Ree, U.S. Dept. of Agric., *ARS-S-126*, 11 pages, July 1976.

Rooftop Runoff for Water Supply, W. O. Ree, U.S. Dept. of Agric., *ARS-S-133*, 10 pages, Aug. 1976.

Effect of Seepage Flow on Reed Canarygrass and Its Ability to Protect Waterways, W. O. Ree, U.S. Dept. of Agric., *ARS-S-154*, 8 pages, Nov. 1976.

Friction Factors for Vegetated Waterways of Small Slope, W. O. Ree, F. R. Crow, U.S. Dept. of Agric., *ARS-S-151*, 56 pages, Jan. 1977.
Performance Characteristics of a Grassed-Waterway Transition, W. O. Ree, U.S. Dept. of Agric., *ARS-S-158*, 11 pages, Feb. 1977.

302-09286-810-00

PREDICTING RUNOFF AND STREAMFLOW FROM AGRICULTURAL WATERSHEDS IN THE SOUTHEAST

(*b*) Cooperative with the Univ. of Georgia Agric. Exp. Sta., Univ. of Florida Agric. Exp. Sta., Soil Conservation Service, and the South Florida Water Management District.
(*c*) Loris E. Asmussen, Geologist and Technical Director, Southeast Watershed Research Program, USDA-Agricultural Research Service, P.O. Box 5677, Athens, Ga. 30604.
(*d*) Experimental, theoretical, and field investigation; basic and applied research.
(*e*) Determine statistics of rainfall and runoff, develop methods to estimate design values of runoff and streamflow for basin development, build models to predict hydrologic response of watersheds with improved agricultural management. Watershed processes will be conceptualized in mathematical models, each specific to a prediction problem. Models will be verified and improved through field research on agricultural watersheds in the Coastal Plains of Georgia, North Carolina, Florida, and Mississippi, but centered in Little River, Tifton, Georgia. Basin precipitation, streamflow, groundwater, and climate data will be processed by mathematical-statistical techniques to develop base data and model components. Mapping techniques will be developed to incorporate physical, geological, and management practice characteristics in the models.
(*g*) A comprehensive report of Taylor Creek, Fla., is being made to determine the effect of channelization and water level control structure on streamflow and groundwater. Streamflow and groundwater duration analyses have been made. Phreatic water profiles near the main stream show little effect of channelization. Evapotranspiration averaged 35.2 inches per year and did not change with channelization. Annual and 4-month water-yield analyses showed no significant effects of channelization. Streamflow duration (cfs) shows that after channelization durations of high flows and low flows are greater than before channelization while the duration of intermediate flows is less than before channelization. Groundwater duration showed that channelization and control structures had little effect. Fifty years of rainfall records at 16 Coastal Plain Weather Bureau locations have been analyzed for seasonal probabilities of specified precipitation amounts and for quarterly number of drought days for specified recurrence intervals. Continuous stage data for the Little River Streamflow are stored on magnetic tape for the period, 1968-1975. Filling and coding of missing data periods through 1975 was completed. Programs have been developed for building discharge tapes and for computing and storing summary information such as mean daily discharge, maximum daily instantaneous discharge, and daily area runoff. Daily alluvial groundwater discharge has been computed for Stations I, J, and K for the record period, 1971 to 1976.
A land-cover map of Little River Watershed being prepared from Landsat imagery will be compared to "ground truth" maps derived from conventional sources. This is a step in examination of satellite imagery as a possible source for acquiring and maintaining up-to-date physiographic watershed data necessary for accurate runoff prediction. A sub-model of a previously developed storm event model computes watershed distributed rainfall, partitioned into runoff and not-runoff amounts, thus forming maps of storm potential runoff across the watershed.. Newly developed mathematical cascading techniques route this runoff overland and downchannel to form the storm hydrograph at watershed outlet, making it possible to account for the magnitude and location of various watershed management changes and to calculate explicitly their effect on the hydrograph. Development of a regional streamflow recession model is continuing while a groundwater recession model for Florida watersheds is being developed. Techniques employing probability generating functions derived for transforming the probabilistic structures of rainfall and hydrologic system state to obtain a probability distribution of system output were translated into a computer program. The program is structured in modular form so that different deterministic or parameteric hydrologic models can be inserted, providing selection of the hydrologic model best suited to a specific evaluation or planning problem.
(*h*) **Continuous Seasonal Probability of Extreme Rainfall Events,** W. M. Snyder, *Hydrological Sciences Bull.* **20**, 2, pp. 275-283, June 1975.
A System for Computer Reduction of Digital Precipitation Data, T. K. Woody, published *Proc. Natl. Symposium Precipitation Analysis for Hydrologic Modeling*, Amer. Geophys. Union, pp. 18-27, June 1975.
A System for Collection and Translation of Digital Precipitation Data, W. G. Knisel, Jr., published *Proc. Natl. Symp. Precipitation Analysis for Hydrologic Modeling*, Amer. Geophys. Union, pp. 7-17, June 1975.
Stochastic Time Distribution of Storm Rainfall, W. G. Knisel, Jr., W. M. Snyder, *Nordic Hydrology* **6**, pp. 242-262, 1975.
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Developing a Parametric Hydrologic Model Useful for Sediment Yield, W. M. Snyder, *Proc. Sed.-Yield Workshop*, Oxford, Miss. USDA, *ARS-S-44*, pp. 220-230, June 1975.
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A Proposed Index for Comparing Hydrographs, R. H. McCuen, W. M. Snyder, *Water Resources Research* **11**, 6, pp. 1021-1024, Dec. 1975.
Time Series Data Analysis and Synthesis for Research Watersheds, W. M. Snyder, USDA, *ARS-S-112*, 33 pages, Jan. 1976.
Estimation of Pond Evaporation in the Georgia Coastal Plain, R. H. McCuen, L. E. Asmussen, USDA, *ARS-S-89*, Mar. 1976.
Interpolation and Smoothing of Experimental Data with Sliding Polynomials, W. M. Snyder, USDA, *ARS-S-83*, 34 pages, Apr. 1976.
The Variability of the Net Radiation Ratio, R. H. McCuen, L. E. Asmussen, *Nordic Hydrology* 7, pp. 135-144, 1976.
Calibration of Selected Infiltration Equations for the Georgia Coastal Plain, W. Rawls, P. Yates, L. Asmussen, USDA, *ARS-S-113*, pp. 1-110, 1976.
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Design Construction and Operation of Streamflow Measuring Facilities in the Little River Watershed, Georgia, P. Yates, *ARS-S-148*, 15 pages, Oct. 1976.

302-09287-860-00

DEVELOP METHODS FOR EVALUATING, PREDICTING, AND REDUCING POLLUTION OF SOIL, WATER, AND AIR BY AGRICULTURAL CHEMICALS

(*b*) Cooperative with Univ. of Georgia Agric. Exp. Sta., Univ. of Florida Agric. Exp. Stat., Soil Conservation Service, and the Central & Southern Florida Flood Conservation District.

(*c*) Loris E. Asmussen, Director. USDA-ARS, Athens, Ga., Area Southeast Watershed Research Program, P.O. Box 5677, Athens, Ga. 30604.
(*d*) Experimental, theoretical, and field investigation; basic and applied research.
(*e*) Develop methods for evaluating, predicting, and reducing pollution of soil and water by mineral matter and chemicals and model the movement of agricultural minerals and chemicals from and within agricultural land. Concentration and load of chemicals and minerals will be related to hydrologic parameters, cultural practices, and land-physical descriptions.
(*g*) Chemical and sediment concentration and load was determined from complex-cover agricultural watersheds for the period 9/74 to 12/76. Both sediment and agricultural chemical load were determined to be quite low on these Southeastern Coastal Plain Watersheds. Samples of surface and subsurface flow from natural rainfall events were collected from two small (0.85 and 0.106 ac) single-cropped (soybeans–spring, summer, and fall, oats–winter) watersheds treated with treflan and MSMA. Pesticides as well as nitrate + nitrite-nitrogen, orthophosphorus, chloride and conductivity determinations were made. Maximum observed MSMA concentration was 72 ppb. Maximum observed treflan concentration in surface runoff was 19 ppb. Subsurface runoff did not contain detectable levels of treflan. Simulated rainfall events were applied to small (512 ft^2) subplots of Z at intervals of 2, 9, and 33 days after pesticide application to determine the persistence of treflan and MSMA in surface runoff. Maximum observed treflan concentration was 22 ppb. Soil samples were also taken to determine the persistence of these pesticides in the upper 24 inches of the soil. Grassed waterway tests were conducted to determine the reduction of pesticide load in runoff flowing down a grassed waterway. Water quality has been surveyed at approximately 2-week intervals at selected locations in Taylor Creek watersheds. Characteristics surveyed include nitrate-nitrogen, ortho-phosphorus, conductivity, and chloride from dairy, beef, and citrus areas of the watershed.
(*h*) **Seasonal Variation in Water Quality of Streamflow in the Coastal Plain of Georgia,** L. E. Asmussen, Ga. Coastal Pl. Exp. Sta., Univ. of Ga., *Res. Bull. 168*, 1975.
A Model for Runoff of Pesticides from Small Upland Watersheds, R. R. Bruce, L. A. Harper, R. A. Leonard, W. M. Snyder, A. W. Thomas, *J. Environ. Qual.*4, 4, pp. 541-548, 1976.
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Seasonal Variation in Runoff and Water Quality in the Taylor Creek Watershed, Okeechobee County, Florida, L. H. Allen, Jr., E. H. Stewart, W. G. Knisel, R. B. Slack, *Soil & Crop Sci. Soc. of Florida Proc. 34*, pp. 126-138, Nov. 18-20, 1975.
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Nutrient Movement in Streamflow from Agricultural Watersheds in the Georgia Coastal Plain, L. E. Asmussen, J. M. Sheridan, C. B. Booram, Jr. Abstract presented at ASAE Winter Mtg.
MSMA Losses in Runoff from Small Watersheds in the Mississippi Delta and Georgia Coastal Plain, R. D. Wauchope, L. E. Asmussen, E. W. Hauser, Jr. Abstract published in *Proc. Sou. Weeds Sci. Soc.* **30**, 1977.
Water Quality Inventory of the Southern Coastal Plain and Atlantic Coast Flatwoods of Georgia, L. E. Asmussen, J. M. Sheridan, H. D. Allison, Agr. Res. Serv., USDA, *ARS-S-49*, pp. 1-27, 1975.

302-09290-220-00

EFFECTS OF BED FORMS ON THE SUSPENSION AND BEDLOAD TRANSPORT OF SEDIMENT

(*c*) Joe C. Willis, Research Hydraulic Engineer, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.
(*d*) An analytical and experimental investigation of the basic mechanics of bed forms and bedload transport. Part of the results were applied to a Doctoral thesis at the University of Iowa.
(*e*) Statistical descriptions of bed forms along with measurement of the total sand load were obtained for different flows and temperatures in a laboratory test channel. These data were analyzed according to a theoretical derivation of the bed load from bed-form spectra.
(*f*) Nearing completion.
(*g*) A new method was derived for calculating the bed load as the sum of contributions by Fourier frequency components of bed-elevation records. The amplitude of each component was taken proportional to the contribution to the total standard deviation, which was obtained by differentiating the variance (spectral density). The celerity of each component was computed from cross spectral phase angles between two records from points separated 0.5 ft along the flume. The sum of the bed load computed by this method and the suspended load computed from published models for the velocity and concentration distributions agreed well with the measured sand load. No effects of temperature on bed-form properties were indicated by the experimental data.
(*h*) **Sediment Discharge of Alluvial Streams Calculated from Bed-Form Statistics,** J. C. Willis, *Ph.D. Thesis*, University of Iowa, 200 pages, Dec. 1976.

302-09292-200-00

TIME AND SPATIAL DISTRIBUTION OF BOUNDARY SHEAR STRESS IN OPEN CHANNEL FLOWS

(*b*) Cooperative with the University of Mississippi and the U.S. Army Corps of Engineers.
(*c*) C. V. Alonso, Research Hydraulic Engineer, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.
(*d*) Experimental and theoretical; basic and applied research.
(*e*) Computer-aided experimental studies to determine the spatial distribution of instantaneous shear stresses exerted by turbulent flows on open-channel boundaries. These boundary stresses are being measured in an 18-meter recirculating flume using hot-film anemometry techniques. The anemometer signals are digitized in a real-time mode, and subsequently subject to time-series analysis in order to evaluate the stochastic properties of the boundary unit tractive forces.

302-09293-220-00

LOCAL FLOW AND FORCES EXERTED ON A STREAMBED PARTICLE

(*c*) N. L. Coleman, Geologist, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.
(*d*) Experimental, basic and applied research.
(*e*) Laboratory experiments to determine lift and drag coefficient functions for particles on a streambed. Measurements of drag and lift forces, flow velocities, and other relevant variables are being made during experiments in a water tunnel.

(*f*) Near completion.

302-09294-350-00

DESIGN CRITERIA FOR WATER CONTROL STRUCTURES

(*b*) Cooperative with the University of Mississippi, Mississippi State University and the Soil Conservation Service.
(*c*) Dr. W. C. Little, Hydraulic Engineer and Mr. J. B. Murphey, Geologist, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.
(*d*) Field and laboratory investigations; basic and applied research.
(*e*) Develop and evaluate techniques for the design of riprap grade control structures. Investigate, by hydraulic model studies and field studies, the optimum geometry of energy dissipation pools for loose-rock drop structures. Areas of investigation include the influence of plan geometry, channel shape, channel gradient, flow parameters and rock size. Additionally, various techniques for energy dissipation within a preformed scour hole are being investigated.
(*g*) Model studies have shown that additional energy dissipation mechanisms are needed even with preformed, rock lined scour holes. Model studies showed that when the ratio of specific head to drop is greater than one, a well-developed hydraulic jump does not occur and an undulating jump generates undesirable standing waves which persist large distances downstream. Various forms of both baffle blocks and baffle plates have been shown to be extremely effective in destroying the undulating waves and reducing the erosion potential of the water as it enters the downstream channel. Prototype structures of two structures have performed well.

302-09295-300-00

STREAM CHANNEL STABILITY

(*b*) Cooperative with the University of Mississippi, Mississippi State University and the Soil Conservation Service.
(*c*) Dr. Earl H. Grissinger, Soil Scientist and Dr. W. C. Little, Research Hydraulic Engineer, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.
(*d*) Field and laboratory investigations; basic and applied research.
(*e*) Using multivariate statistical techniques, identify the soil physiochemical properties that are significant channel erodibility parameters and statistically relate eroding shear stress to the soil parameters.
(*g*) Field erodibility studies, using a portable flume, were continued. Analysis of the data at hand indicates the stability of fine grained materials of low plasticity indices cannot be adequately described by the D_{50} value. Sample morphology, clay content, and infiltration (wetting) characteristics influenced the measured erosion rates. In general, the measured erosion rates varied inversely with sample clay content. The rates were excessive for samples which had visible, but small scale, sand lensing or other zones of relative weakness and for samples of low hydraulic conductivity which were initially tested at low antecedent water content. The pin hole test appears to have potential as a "quick" measure of erodibility for materials of this type.

302-09296-220-00

SEDIMENT PROPERTIES THAT AFFECT AGRICULTURAL CHEMICAL TRANSPORT

(*b*) Cooperative with Mississippi Agricultural and Forestry Experiment Station and with the Forest Hydrology Laboratory, USDA Forest Service.
(*c*) L. L. McDowell and J. D. Schreiber, Soil Scientists, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.
(*d*) Laboratory and field investigations; basic and applied research.
(*e*) Determine quantity and forms of farm chemicals transported in surface runoff from upland and Delta croplands; evaluate relative significance of solution-and sediment-phase chemical transport; evaluate minimum tillage practices for reducing chemical losses from farmlands; determine physical and chemical properties of sediments that affect chemical transport; develop sediment-water-chemical relationships needed for predicting the transport of farm chemicals.
(*g*) Toxaphene, DDT, DDE, P and clay yields in runoff from flat cotton land (mean slope 0.2%) in the Mississippi Delta were linearly related to sediment yield (cooperative research with the USDA-ARS Soil and Water Pollution Research Unit, Baton Rouge, La.). Mean sediment yield was 27.6 metric tons/ha/year when mean annual rainfall was 43.8 cm above the 30-year average of 125 cm. Improved erosion control practices are needed on Delta lands during the tillage period when the major portion of the annual sediment and farm chemical yields is produced. Rapid decrease in toxaphene concentrations in the soil and in sediment in runoff, following application, suggests that other processes such as volatilization and degradation, are responsible for its rapid dissipation. Aerodynamic and energy balance methods were used to measure the volatilization rates of dicofol, toxaphene, and DDT from post application to cotton in an USDA-ARS cooperative field study (1976) by personnel from Baton Rouge. La., Watkinsville, Ga., and Oxford, Miss.

N, P, and chemical oxygen demand (COD) losses in runoff and sediments from no-till corn grown on highly erodible upland soils in north Mississippi were 9, 1.7, and 96 kg/ha, respectively, compared to 118, 21, and 1075 kg/ha from conventional till. Crop residues can contribute significant concentrations and yields of soluble organic carbon (C) to runoff. Mean annual concentrations of organic C in runoff were 10.3 and 7.8 mg/l from no-till corn for grain (residues left) and silage, respectively, compared with 7.4 and 4.8 mg/l from conventional till grain and silage. By controlling erosion, no-till is effective in reducing sediment and total plant nutrient yields in runoff from agriculture.

Total P yields (aqueous + sediment) in runoff from pine watersheds on loessial and Coastal Plain soils in north Mississippi were low, averaging only 300 g/ha. Total dissolved P input to the watersheds in rainfall was 400 g/ha, indicating a net gain of P to the watersheds. Of the total P lost from the watersheds, 70 percent was transported via suspended sediment; the rest, in solution. Even though sediment yields were low (185 to 950 kg/ha), the major part of the total P loss was via suspended sediment.

(*h*) **Erosion and Water Quality,** L. L. McDowell, E. H. Grissinger, *Proc. 23rd Natl. Watershed Congress*, pp. 40-56, 1976.

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302-09297-220-00

SEDIMENT DEPOSITION

(*b*) Cooperative with the University of Mississippi, the Mississippi Agricultural and Forestry Experiment Station, University of Wisconsin-Madison, University of Minnesota-

Minneapolis, the Great River Environmental Action Team I, the Vicksburg, District, U.S. Army Corps of Engineers, and the U.S. Soil Conservation Service, Jackson, Mississippi and St. Paul Minnesota.

(*c*) Roger McHenry, Soil Scientist; F. E. Dendy, Hydraulic Engineer; J. C. Ritchie, Soil Scientist; F. R. Schiebe, Hydraulic Engineer; C. M. Cooper, Biologist; J. May, Chemist; USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.

(*d*) Experimental laboratory and field studies; basic and applied research.

(*e*) Evaluate watershed, reservoir, hydrologic, hydraulic, chemical, and microbiological parameters which affect, or are affected, by the rates, amounts, character and areal distribution of sediment in reservoirs, lakes, streams, estuaries and valleys. Study the biochemical, physiochemical, and geohydrological aspects of sediment-water systems in lakes, impoundments, and estuaries and relate these to management techniques. Design, develop, test, evaluate, modify, and adapt techniques, methods and instrumentation to characterize significant variables in sediment-water systems in field and laboratory. Compile and analyze existing reservoir sedimentation data including trap efficiency percentages directly by inflow and outflow measurements and indirectly using nuclear and remote sensing techniques. Sedimentation rates and ages are determined by nuclear means and remote sensing techniques are applied to re-evaluation of sedimentation data. Data collection automation and mathematical modeling by digital computer of sedimentation rates and parameters are essential.

(*g*) Measurements of sediment detention in three small north Mississippi watersheds built in 1953, indicate deposition rates of sediment have decreased from 2.00 to about 0.4 ac ft/yr. Annual loss of storage in the reservoirs decreased from 2.3 ~ 2.9 percent to less than 1 percent. At these rates, the useful life of these structures will substantially exceed their 50-year design life. Automatic recording equipment and pumping type samplers have been installed on the Bear Creek Watershed, Yazoo Basin, Mississippi and velocity, stage, pH, DO, temperature, and conductivity of Bear Creek are monitored continuously and sediment concentration and chemical loads are determined from pumped samples. One year's data have been collected from manual monitoring stations on Bear Creek. Similar data are being collected on Lake Chicot, southeastern Arkansas. Preliminary findings indicate dissolved oxygen is limited during the later summer, even in the deeper oxbow lakes. Turnover of lake water in these delta lakes occurred in September, before the dissolved oxygen content rose. Chemical concentrations were high but daily discharges were so low that the observed high chemical concentrations may be misleading.

Measurements of within field soil erosion by determining the fallout Cs-137 content of soil profiles shows promise. With this technique it may be possible to determine the factor applicable to a given field or watershed to convert the USLE values to actual field soil losses. The Cs-137 technique was used also to evaluate the rate of sedimentation in Pool 9, upper Mississippi River. In calm areas up to 2 feet of sediment has accumulated since 1937. The amounts deposited from 1937 to 1954 and from 1954 to date appear about equal. The apparent rate of deposition has not differed significantly in the past 40 years.

Measurements of temperature, pH, conductivity and dissolved oxygen in six north Mississippi reservoirs all indicated stratification in the reservoir but such stratification was not correlated with suspended sediment stratification. A positive relationship was found, however, between the extinction coefficient of white light and concentration of suspended sediment. Thus determinations of the extinction coefficient profile with depth in a reservoir or lake can be related to the suspended sediment concentration profile. In field use it was found that this method needed individual site calibration to provide quantitative information. In another study the absorption of solar radiation in the surface waters of large water bodies was determined for individual wavelengths and the whole spectrum. Measurements of this absorption by water with various suspended sediment concentrations indicated that suspended sediments do influence the amount of solar radiation absorbed.

A series of studies have shown that the total suspended sediment load of a water body can be reliably estimated from the concentration of suspended sediments in the surface water. It has been shown in north Mississippi that measurements of reflected solar radiation can be used to estimate the suspended sediment concentration of surface waters. It appears possible to determine quickly and accurately the total sediment load in a large reservoir or lake by measuring the reflected solar radiation using aerial or satellite imagery. Such a method would permit almost an instantaneous measurement of the suspended sediment in a reservoir.

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302-09298-830-00

SOURCE AND MAGNITUDE OF SEDIMENT FROM SMALL WATERSHEDS

(*b*) Cooperative with Mississippi Agricultural and Forestry Experiment Station and the Soil Conservation Service.

(*c*) Calvin K. Mutchler, Research Leader, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.

(*d*) Experimental; applied and basic research.

(*e*) Develop methods for describing and controlling the movement of water and sediment from upland, field, and channel sources to a watershed outlet. The field facilities are 1) Pigeon Roost Creek Watershed in North Mississippi, consisting of ten subwatersheds covering 117 square miles; 2) six flatland watersheds in the Mississippi Delta, a divided one of 83 acres, a natural Delta watershed of 640 acres, two 7-acre graded field segments and two 5-acre ungraded fields; 3) Toby Tubby Creek Watershed, 1000 acres and partly urbanized; 4) erosion plots sited on the North Mississippi Branch Experiment Station; and 5) a rainulator and computer facilities shared with other research units at the Laboratory. Primary objectives of the research are to document runoff and sediment yield from watersheds under changing cover, agricultural usage, and urbanization; to determine delivery ratios and other sediment yield prediction methods; to develop methods for controlling erosion from farm fields and other watershed sediment sources; to investigate hydraulic and hydrologic effects of channel dredging; to determine effects of urbanization on water and sediment yield.

(*g*) The no-till system reduced soil losses from corn grown on a five-percent slope to less than 0.5 tons per acre. When the corn was cultivated twice for weed control, soil losses were maintained at less than 1 ton per acre.

Calculations made using raindrop data collected in northern Mississippi supported the use of the Wischmeier and Smith equation for calculating the rainfall erosion index used in the universal soil loss equation.

Data from a Mississippi Delta watershed show that erosion can be a serious problem on very low slopes. Estimates for annual soil loss from normal rainfall were about 7 tons per acre from cotton grown on a slope of 0.2 percent.

Roughness coefficients for two sand bed channels in Pigeon Roost Creek Watershed varied with stage and time. The variation was attributed to changing bed forms and bank-bed resistance differences.

Two-year annual sediment yield from a 640-acre Delta watershed was about 2 tons per acre. This watershed has natural land slopes and has numerous small impoundments that are typical of many Delta watersheds.

(*h*) **Erosion Measured from a Lister-Till System,** J. D. Greer, K. C. McGregor, G. E. Gurley, B. R. Arnold, *Proc. Water Resources Conf.*, Apr. 29, 1976.

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302-10628-250-00

TURBULENT CHARACTERISTICS OF DRAG-REDUCING FLOWS

(*b*) Cooperative with the University of Mississippi.

(*c*) C. V. Alonso, Research Hydraulic Engineer, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.

(*d*) Experimental; basic research.

(*e*) Turbulence measurements were made in water and in polyethylene oxide aqueous solutions, using hot-film anemometry. Mean velocities, turbulent intensities, energy spectra, and energy-dissipation rates were measured in a turbulent smooth-pipe flow.

(*f*) Completed.

(*g*) Mean flow structure showed that the mean velocity follows Virk's interactive-layer profile, and that the wall shear velocity is the proper velocity scale for polymer flows. Using Lumley's concept of an effective viscosity, the polymer spectra were cast into universal form and compared with Newtonian spectra. Results coincide reasonably well with the universal equilibrium theory. The major effect of the polymer additive appears to be an increase of the dissipative scales of the turbulence without significantly altering the basic structure of the flow, except near the wall.

(*h*) **Spectrum Analysis of Water and Drag Reducing Polymers in Pipe Flow,** W. H. Klaus, *M.Sc. Thesis*, Dept. Mech. Engrg., Univ. of Mississippi, 1973.

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302-10629-200-00

ANALYSIS OF SURFACE FLOWS OVER PARTIALLY ERODING BEDS

(*b*) Cooperative with the University of Mississippi and the U.S. Army Corps of Engineers.

(*c*) C. V. Alonso, Research Hydraulic Engineer, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.

(*d*) Theoretical; basic and applied research.
(*e*) Development of an analytical steady-state model to calculate the cross-sectional distribution of velocity and boundary tractive force in alluvial channels with regular sections. The wetted perimeter is divided into an inner region in which the known critical tractive forces are exceeded, surrounded by a region where the fluid velocity is known to vanish. This mixed boundary value problem was formulated in terms of a dual series which lead to the solution of a Fredholm integral equation of the second kind. This solution determines the extent of the eroding zone and the distribution of the bed-slip velocity.
(*g*) Close-form solutions have been obtained for the particular cases of rectangular channels with incipient erosion at the bed center, and with fully eroding bed. In the first case, the agreement between the predicted maximum unit tractive forces and available experimental data is satisfactory. In the second case, the analysis predicts an outward shift of the isotachs that leads to a significant increase of the wall unit tractive forces. This finding is significant increase of the wall unit tractive forces. This finding is significant in that it may help to explain the severe bank erosion observed in alluvial channels following dredging operations. Research continues on the general analysis of a bed eroding over an arbitrary span, and the extension to other cross-sectional shapes.
(*h*) **Integral-Equation Analysis of Flows Over Eroding Beds,** S. N. Prasad, C. V. Alonso, *Proc. ASCE Symp. Inland Waterways for Navigation, Flood Control and Water Diversions* **I,** pp. 760-772, 1976.

302-10630-220-00

COMPUTER SIMULATION OF LOCALIZED SCOUR AROUND OBSTRUCTIONS IN ERODIBLE-BED CHANNELS

(*b*) Cooperative with the University of Mississippi.
(*c*) C. V. Alonso, Research Hydraulic Engineer, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.
(*d*) Theoretical; basic and applied research.
(*e*) Development of a three-dimensional finite-element model to calculate the erosive flow pattern around bridge piers, spur dikes, and similar obstructions in alluvial channels. The purpose of the model is to predict the evolution in time of the scour around structures so that they can be designed against undermining and failure.

302-10631-810-00

COMPUTATIONAL MODELS FOR ROUTING WATER AND SEDIMENT IN AGRICULTURAL WATERSHEDS AND ASSOCIATED STREAM-CHANNEL SYSTEMS

(*b*) Cooperative with the University of Mississippi and the U.S. Army Corps of Engineers.
(*c*) C. V. Alonso and D. G. DeCoursey, Research Hydraulic Engineers, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.
(*d*) Develop a continuous simulation watershed model that will include water and sediment components. The model will be oriented towards providing planners with an adequate tool to assess alternative watershed management practices. Computational modeling techniques will be used to simulate the physical processes by which water and sediment move from the upland areas down to the channels draining the watersheds. The processes to be modeled include rainfall interception, runoff, infiltration and groundwater movement, evapotranspiration, sediment production due to raindrop impact, sheet erosion and streamflow entrainment, and movement of water and sediment through the channel system. A nonlinear kinematic-wave scheme will be used to simulate the movement of water and sediment overland and in small streams, while a nonlinear dynamic-wave scheme will be developed to describe total sediment concentration and both channel aggradation and degradation along larger channel systems. This model will be subsequently incorporated into a systems analysis approach to watershed problems. Such an approach will enable consideration of watershed-dynamics in terms of specific objectives and, at the same time, implementation of the objectives through optimization techniques.

302-10632-830-00

SOIL EROSION PRINCIPLES AND PROCESS

(*b*) Cooperative with the Mississippi Agricultural and Forestry Experiment Station.
(*c*) L. D. Meyer, Agricultural Engineer, and M. J. M. Römkens, Soil Scientist, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.
(*d*) Analytical, experimental, and field studies; basic and applied research.
(*e*) Investigate basic principles and processes of soil detachment, transport, and deposition by rainfall and upland runoff. Study water movement across and into the soil as it affects erosion and runoff rates. Evaluate erosion, runoff, and sediment characteristics for typical land uses. Develop improved methods of predicting soil erosion and infiltration rates. Design improved equipment to conduct soil erosion research. Identify soil characteristics that influence soil erosion and infiltration. Develop better management practices for controlling upland soil erosion by water.
(*g*) Concepts and methods were developed to separate soil eroded from upland sources into that from rills, due primarily to concentrated runoff, and that from interrill areas between rills, due primarily to raindrop impact. The amount of iron and aluminum oxide content was shown to affect soil erodibility, particularly on high-clay soils. Sediment from well-aggregated soils was found to often be much coarser than the dispersed sediment and thus affect sediment transportability. A rainfall simulator with a wide range of intensities was developed for row-sideslope erosion research on typical field conditions. Methods of using Portland cement for soil stabilization were evaluated.
(*h*) **Influences of Mulch Rate and Slope Steepness on Interrill Erosion,** A. R. Lattanzi, L. D. Meyer, M. F. Baumgardner, *Soil Sci. Soc. of Amer. Proc.* **38,** 6, pp. 946-950, Nov.-Dec. 1974.

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302-10633-300-00

STREAM CHANNEL MORPHOLOGY AND STABILIZATION AND PRACTICES FOR WATER EROSION

(*b*) Cooperative with the University of Mississippi.
(*c*) W. C. Little, Research Hydraulic Engineer, and E. H. Grissinger, Soil Scientist, USDA Sedimentation Laboratory, P.O. Box 1157, Oxford, Miss. 38655.
(*d*) Field investigations.
(*e*) Determine mode and causes of channel instabilities and develop, test and evaluate techniques and criteria for design, stabilization and maintenance of stream channels. Investigate, by model and field studies, mode and causes of bank failures and methods and means of channel stabilization and protection. Determine by both laboratory and field experiments the effects of geology, geomorphology, soils, land use and climate on runoff and sediment production and the integrated effects of these factors on channel stability.

302-10634-810-00

MODELING STORM RAINFALL PATTERNS IN THE SOUTHERN GREAT PLAINS

(*c*) Dr. A. D. Nicks, Agricultural Engineer, and E. H. Seely, Hydraulic Engineer, USDA, Agricultural Research Service, P.O. Box 400, Chickasha, Okla. 73018.
(*d*) Field studies and analysis; basic and applied research.
(*e*) Deterministic and stochastic models of rainfall patterns will be developed by classifying and analyzing at least 12 years of storm data collected from a dense rain gage network. Nonlinear least squares and principal components regression techniques will be used in the analysis to estimate parameters of both storm- and area-centered depth-area-duration relationships. Storm rainfall patterns will be characterized by amount, duration, pattern shape, size and orientation, and statistical distribution of the characteristics will be constructed. Parameters of these distributions and Monte Carlo sampling techniques will be used to develop synthetic records of rainfall. The approach used will be oriented toward modeling runoff producing storm events of a size pertinent to the design of flood control and water supply reservoirs and aiding the development and testing of hydrologic models on watersheds ranging from 1 to 300 square miles in area. Purpose of the work is to develop improved deterministic and stochastic models of areal rainfall patterns as related to maximum depth, storm duration, and frequency of storm occurrence.
(*g*) The model has been tested on several large storms in the Great Plains, Black Hills, and Enid, as well as storms occurring on the Chickasha network. It was concluded that the model has predictive capability in other areas of the Great Plains.
(*h*) **Stochastic Generation of Hydrologic Model Inputs,** A. D. Nicks, *Dissertation*, Univ. Oklahoma, 1975.

302-10635-810-00

PREDICTING SEDIMENT YIELDS FROM LARGE AGRICULTURAL WATERSHEDS

(*c*) P. B. Allen, Hydraulic Engineer and N. H. Welch, Soil Scientist, USDA, Agricultural Research Service, P.O. Box 400, Chickasha, Okla. 73018.
(*d*) Field studies and analysis; basic and applied research.
(*e*) Deterministic sediment predictive models for large watersheds require a channel transport capability component in addition to land erosion variables. Using existing transport equations as guides and sediment transport data from seven gaged watersheds, a new transport relation will be developed for the Southern Plains. After removing the transport effects from the sediment yield data, regression and optimization techniques will be used to develop the land erosion portion of the model. Parameters of the erosion portion of the model will be similar to those used in the Universal gross erosion equation. However, an attempt will be made to use parameters that do not use the prohibitively large amount of time and effort that is required in using the Universal equation. An improved rainfall energy-intensity relation (EI) will be sought. The purpose of the work is to develop a sediment prediction model capable of predicting sediment yield from large (20 to 200 sq.mi.) agricultural watersheds in the Southern Plains. The model will be able to predict storm sediment yield under different basin management patterns by particle sizes, and from reasonably available input data.
(*g*) Sets of turbidimeter readings and suspended sediment concentrations were critically analyzed to determine if a turbidimeter could be used for routine measurement of sediment concentrations. It was concluded that the turbidimeter was too inaccurate for research studies because the readings are sensitive to changes in particle size. The meter is more sensitive to fine particles than to coarse particles. Percentages of area in each soil type in six tributary watersheds have been compiled for watershed modeling studies. Separate soil areas in each Thiessen rainfall area of one watershed have also been compiled.
(*h*) **Total Sediment Load by the Extrapolated Data Procedure,** P. B. Allen, B. B. Barnes. In: *Present and Prospective Technology for Predicting Sediment Yield and Sources*, pp. 100-108, *USDA-ARS-S-40*, 285 pages, 1975.

302-10636-810-00

PREDICTION OF SEDIMENT YIELDS FROM SMALL AGRICULTURAL WATERSHEDS IN THE SOUTHERN PLAINS

(*c*) N. H. Welch, Soil Scientist, and P. B. Allen, Hydraulic Engineer, USDA, Agricultural Research Service, P.O. Box 400, Chickasha, Okla. 73018.
(*d*) Field studies and analysis; basic and applied research.
(*e*) Utilize hydrologic data collected from several small unit source watersheds representing various land uses and other sediment source areas to predict sediment yield from small agricultural watersheds. The watersheds include cropland, rangeland, and gullied areas ranging in size from 12 to 45 acres for the cropland and rangeland, and less than 10 acres for the gullied area. The cropland areas are in alluvial soils and consist of dryland and irrigated row crops and dryland winter wheat. The rangeland areas are in good to excellent and poor to fair range condition. Techniques developed on the small watersheds will be used with data from a 35-square-mile subdivided watershed to predict sediment yield from larger and more complex watersheds. The purpose of the work is to develop procedures to predict the amount, rate, source, and character of sediment yield from agricultural watersheds.
(*g*) Gully sediment yields from individual storms on a watershed where the gully occupied 22 percent of the area were highly related to precipitation and runoff. Both linear and logarithmic relations fitted on 2 years of data underestimated storm sediment yields in the succeeding 2 years. Soil properties needed to calculate soil erodibility values were measured on samples from six mapping units. The variability of the calculated erodibility within a mapping unit averaged 30 percent over the six mapping units. Variability of this magnitude could be important in erosion model evaluation, calibration, and prediction.
(*h*) **Sediment Yield Characteristics from Unit Source Watersheds,** pp. 125-129. In: *Present and Prospective Technology for Predicting Sediment Yield and Sources*, E. D. Rhoades, N. H. Welch, G. A. Coleman, *ARS-S-40*, 285 pages, 1975.

The Modified Chickasha Sediment Sampler, P. B. Allen, N. H. Welch, E. D. Rhoades, C. D. Edens, G. E. Miller, *ARS-S-107*, 13 pages, 1976.

302-10637-870-00

CHEMICAL TRANSPORT FROM AGRICULTURAL WATERSHEDS

(*c*) Dr. M. H. Frere, Soil Scientist, Dr. A. D. Nicks, Agricultural Engineer, and J. W. Naney, Geologist, USDA, Agricultural Research Service, P.O. Box 400, Chickasha, Okla. 73018.
(*d*) Field studies and analysis; basic and applied research.
(*e*) Chemical content of water and sediment from various watersheds at Chickasha as well as data in the literature will be used to evaluate existing chemical transport models. Tracers and various chemical analyses will be used to measure and characterize leaching, base flow, and groundwater movement. Additional data indicated by the models will be collected to further verify and improve the models. Purpose of the work is to test, modify or develop models for predicting various chemical pollutants in surface runoff, base flow, groundwater, and sediment from agricultural watersheds.

302-10638-810-00

DEVELOPMENT AND EVALUATION OF HYDROLOGIC MODELS FOR WATERSHEDS IN THE SOUTHERN GREAT PLAINS

(*c*) Dr. A. D. Nicks, Agricultural Engineer, G. A. Gander, Mathematician, and Dr. M. A. Frere, Soil Scientist, USDA, Agricultural Research Service, P.O. Box 400, Chickasha, Okla. 73018.
(*d*) Field studies and analysis; basic and applied research.
(*e*) Various existing continuous simulation models will be tested with data for Southern Great Plains watersheds ranging in size from 10 to 250,000 acres and containing various soils and land uses. The responses of the models to a range of climatic conditions will be tested by using 10 to 15 years of recorded observations. The sensitivity of various model parameters to the climatic and physiographic characteristics of the region and the criteria for selecting values of model parameters will be determined, as well as evaluating the accuracy of the simulated results. Modifications of the models will be coordinated with the testing and development of chemical and sediment transport models to assure compatibility. The purpose of the work is to evaluate and develop continuous simulation models for predicting the water resources of large Southern Great Plains watersheds with mixed and changing land use, and for predicting water movement associated with chemical and sediment transport.

302-10639-860-00

INCREASING THE BENEFICIAL USE OF STREAMFLOW

(*c*) R. R. Schoof, Hydraulic Engineer, USDA, Agricultural Research Service, P.O. Box 400, Chickasha, Okla. 73018.
(*d*) Field studies and analysis; basic and applied research.
(*e*) Transmission loss from selected storm runoff events and base flow will be determined for streams with tandem gaging stations. The effect of dredging two channels on transmission losses will be investigated with before and after measurements. Water will be released from selected floodwater retarding reservoirs during the irrigation season to determine all losses between the reservoirs and irrigated fields. Water budget records will be collected at four floodwater retarding reservoirs and the effect of storage and extensive releases of water from reservoirs for irrigation on the reservoir onsite water loss will be determined. The purpose of the work is to evaluate transmission losses from flow in both natural and dredged channels with storm flows and with irrigation water releases, and to evaluate the impacts of using water stored in floodwater retarding reservoirs for supplemental irrigation in the Southern Plains.

302-10640-820-00

EVALUATION OF ALLUVIAL AND TERRACE DEPOSITS FOR AQUIFER PERFORMANCE AND WATER SUPPLY CAPABILITY

(*b*) Cooperative with the Geology Department, Oklahoma State University, Stillwater; and the Oklahoma Water Resources Board, Oklahoma City.
(*c*) Dr. D. C. Kent, Geologist, Oklahoma State Univ., Stillwater, Oklahoma 74074, and J. W. Naney, Geologist, USDA, Agricultural Research Service, P.O. Box 400, Chickasha, Oklahoma 73018.
(*d*) Field studies and analysis; basic and applied research.
(*e*) A USGS model of groundwater flow will be tested using 10 years of records from the ARS study area. These records include precipitation, streamflow, and groundwater levels and hydrogeologic properties of the alluvium. The calibrated and tested model will then be used to estimate optimum well spacing and safe pumping rates to meet Oklahoma Water Rights laws. The computer output will be used to develop maps of groundwater resources. Purpose of the work is to (1) calibrate and validate an existing mathematical model for predicting changes in groundwater storage; and (2) make preliminary estimates of groundwater storage and determine the maximum yield and corresponding well spacing requirements in the ARS study area of the Washita River basin and Tillman terraces in Tillman County, Oklahoma.
(*g*) A USGS model (Trescott-Pinder) has been calibrated with ARS data in the study reach of the Washita and found to operate adequately.

302-10641-810-00

SEDIMENT YIELD IN RELATION TO WATERSHED AND CLIMATIC CHARACTERISTICS IN THE WESTERN GULF REGION

(*b*) Cooperative with the Texas Agricultural Experiment Station, College Station, Tex. 77843.
(*c*) J. R. Williams, Hydraulic Engineer, Blackland Conservation Research Center, P.O. Box 748, Temple, Tex. 76501.
(*d*) Applied research.
(*e*) Procedures for describing sediment movement from uplands to downstream points are being developed for use in flood control planning, water quality modeling, and land use management. Mathematical models are being developed to predict sediment yields and graphs from small agricultural watersheds. Also sediment routing models are being designed to route sediment yields from small watersheds to the outlets of large watersheds.
(*g*) A sediment-runoff model for predicting sediment yield and runoff from ungaged watersheds was developed by attaching the modified universal soil loss equation (MUSLE) to a runoff model. Techniques for determining the average slope length and gradient of a watershed from topographic maps were developed. Delivery ratios were computed on ungaged watersheds by dividing long-term sediment yield by sheet erosion. Sediment yield was predicted with the sediment-runoff model and sheet erosion was predicted with the USLE. The computed delivery ratios were related to watershed characteristics to obtain a prediction equation for use on ungaged watersheds. A sediment graph model based on an instantaneous unit sediment graph (IUSG) was developed for use on small agricultural watersheds. The IUSG is the distribution of sediment from a burst of rainfall that produces one unit of runoff. Thus the IUSG is convolved with source runoff to obtain the storm sediment graph.
(*h*) **Predicting Sediment Yield Frequency for Rural Basins to Determine Man's Effect on Long-Term Sedimentation, J. R.** Williams, *Proc. Paris Symp., IAAS-AISH Publ. No. 113*, pp. 105-108, Sept. 1974.

Sediment Routing for Agricultural Watersheds, J. R. Williams, *Water Resources Bulletin, AWRA* **11**, 5, pp. 965-974, 1975.

Sediment-Yield Prediction with Universal Equation Using Runoff Energy Factor, *ARS-S-40*, pp. 244-252, 1975.

302-10642-870-00

PREDICTION OF WATER QUALITY AS AFFECTED BY FERTILIZER APPLIED TO AGRICULTURAL WATERSHEDS

(*b*) Cooperative with the Texas Agricultural Experiment Station, College Station, Tex. 77843.
(*c*) J. R. Williams, Hydraulic Engineer, Blackland Conservation Research Center, P.O. Box 748, Temple, Tex. 76501.
(*d*) Applied research.
(*e*) Mathematical models are being developed to predict nitrogen and phosphorus yields from small agricultural watersheds and to route N and P through streams and valleys to large reservoirs and rivers. Also a land management model is being developed to maximize agricultural production on a watershed within sediment, N, and P constraints at the outlet. These models will be useful in planning water resources projects and land management.
(*g*) A sediment-phosphorus-nitrogen model (SPNM) is being developed to predict sediment, P, and N yields for individual storms on small watersheds and to route these yields through streams and valleys. Sediment predictions are based on the modified universal soil loss equation and sediment routing. N and P yields are predicted with equations developed by Midwest Research Institute for EPA. The equations related annual N and P yield to annual sediment yield, soil concentrations, and enrichment ratios. SPNM applies the equations to single storms so the variation in soil concentration between fertilizer applications can be included. Also, since sediment routing is used, particle size distribution is always available for computing enrichment ratios.

302-10643-810-00

RUNOFF CHARACTERISTICS OF AGRICULTURAL WATERSHEDS IN THE WESTERN GULF REGION

(*b*) Cooperative with the Texas Agricultural Experiment Station, College Station, Tex. 77843.
(*c*) C. W. Richardson, Agr. Engr., Blackland Conservation Research Center, P.O. Box 748, Temple, Tex. 76501.
(*d*) Experimental, field investigations; applied research and development.
(*e*) Precipitation amounts and intensities and resulting rates and amounts of runoff are being determined from agricultural watersheds in central Texas. Soil water measurements are made on selected watersheds. The data are used to define the effects of crops, agricultural treatments, and watershed physical characteristics on the quantity and spatial and temporal distribution of surface runoff.
(*g*) Hydrologic effects of rangeland brush control by chemical and mechanical methods were evaluated. In the Blackland Prairie of Texas a small watershed infested with honey mesquite was treated with a herbicide to kill the mesquite. Runoff data was compared to that from an untreated area. The results indicate that killing the mesquite increased surface runoff approximately 10 percent. In the Edwards Plateau of Texas the brush on a small watershed with mixed species of brush was removed by mechanical root plowing. Surface runoff was reduced approximately 20 percent after root plowing.
(*h*) **Occurrence of 2,4,5-T and Picloram in Surface Runoff Water in the Blacklands of Texas,** R. W. Bovey, E. Burnett, C. W. Richardson, M. G. Merkle, J. R. Baur, W. G. Knisel, *J. Env. Qual.* **3**, pp. 61-64, 1974.
Occurrence of 2,4,5-T and Picloram in Subsurface Water in the Blacklands of Texas, R. W. Bovey, E. Burnett, C. W. Richardson, J. R. Baur, M. G. Merkle, D. E. Kissel, *J. Env. Qual.* **4**, pp. 103-106, 1975.
Losses of Nitrogen in Surface Runoff in the Blackland Prairie of Texas, D. E. Kissel, C. W. Richardson, E. Burnett, *J. Env. Qual.* **5**, 3, pp. 288-302, 1976.

302-10644-810-00

MODELING HYDROLOGIC PROCESSES ON AGRICULTURAL WATERSHEDS IN WESTERN GULF REGION

(*b*) Cooperative with the Texas Agricultural Experiment Station, College Station, Tex. 77843.
(*c*) C. W. Richardson, Agr. Engr., Blackland Conservation Research Center, P.O. Box 748, Temple, Tex. 76501.
(*d*) Experimental, theoretical, and field investigations; basic and applied research.
(*e*) Develop models of hydrologic processes on agricultural watersheds. The processes to be modeled include the stochastic characteristics of precipitation over an area, watershed infiltration and evapotranspiration processes, and other hydrologic processes.
(*g*) A model of the stochastic structure of the time-area daily precipitation process was developed. The square roots of daily precipitation at a point approximated a sample from a truncated univariate normal distribution. Maximum likelihood estimates of daily means and standard deviations were obtained from the truncated samples. The periodic means and standard deviations were described with Fourier series. The truncated multivariate normal distribution was used to describe the time-area variation of daily precipitation over an area. The serial correlation for each station was a regional constant, and the cross correlation between stations was a function of inter-station distance. Precipitation sequences were generated for two areas. The new sequences were not significantly different from the observed sequences in the daily means and standard deviations, the lag-one serial correlation coefficients, the lag-zero cross correlation coefficients, the wet-dry transition probabilities, and the distributions of 28-day and annual precipitation. The model should be useful for generating long samples of daily precipitation over an area for input to deterministic hydrologic models.
(*h*) **Modeling Evaporative Components of Multi-Land-Use Watersheds,** C. W. Richardson, J. T. Ritchie, *Am. Soc. of Agr. Engr. Paper No. 75-2029*, 15 pages, 1975.
Calculating Evaporation from Native Grassland Watersheds, J. T. Ritchie, E. D. Rhoades, C. W. Richardson, *Trans. ASAE* **19**, 6, pp. 1098-1103, 1976.
A Model of Stochastic Structure of Daily Precipitation Over An Area, C. W. Richardson, Colorado State Univ., Dept. Civil Engrg, *Dissertation*, 188 pages, 1976.

U.S. DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE

WESTERN REGION, 2850 Telegraph Avenue, Berkeley, Calif. 94705. Dr. H. C. Cox, Deputy Administrator.

303-0201W-810-00

EFFECT OF RUNOFF, PRECIPITATION, CLIMATE, SOIL, VEGETATION, LAND USE, AND LANDFORM ON SEDIMENT YIELD

See Water Resources Research Catalog **6**, 4.0120.

303-0202W-810-00

CLIMATE, SOIL, AND VEGETATION INFLUENCES ON HYDROLOGY OF RANGELANDS IN THE NORTHWEST

See Water Resources Research Catalog **6**, 7.0093.

303-0226W-820-00

GROUNDWATER RECHARGE AND MANAGEMENT IN CALIFORNIA

See Water Resources Research Catalog **6**, 4.0044.

303-0227W-810-00

CLIMATE, SOIL AND VEGETATION INFLUENCES ON HYDROLOGY OF RANGELANDS IN THE SOUTHWEST

See Water Resources Research Catalog **6**, 2.0045.

303-0228W-810-00

STREAM FLOW REGIMES OF SEMIARID RANGELAND WATERSHEDS IN THE SOUTHWEST

See Water Resources Research Catalog **6**, 2.0046.

303-0229W-810-00

PRECIPITATION PATTERNS ON RANGELAND WATERSHEDS IN THE SOUTHWEST

See Water Resources Research Catalog **6**, 2.0047.

303-0234W-820-00

SOIL WATER MOVEMENT IN RELATION TO THE CONSERVATION OF WATER SUPPLIES

See Water Resources Research Catalog **6**, 3.0004.

303-0235W-840-00

EFFICIENT IRRIGATION AND AGRICULTURAL WATER USE

See Water Resources Research Catalog **6**, 3.0005.

303-0236W-860-00

INCREASING AND CONSERVING FARM WATER SUPPLIES

See Water Resources Research Catalog **6**, 3.0006.

303-0241W-840-00

IRRIGATION SYSTEMS FOR EFFICIENT WATER USE

See Water Resources Research Catalog **6**, 8.0004.

303-0350W-840-00

MANAGEMENT OF IRRIGATION WATER IN RELATION TO CROP REQUIREMENTS, NUTRIENT UTILIZATION AND LABOR REQUIREMENTS

See Water Resources Research Catalog **9**, 3.0122.

303-0351W-840-00

ALLEVIATION OF SALT LOAD IN IRRIGATION WATER RETURN FLOW

See Water Resources Research Catalog **9**, 5.0247.

303-0352W-840-00

DESIGN AND OPERATION OF IRRIGATION SYSTEMS TO MAXIMIZE EFFICIENCIES OF WATER USE

See Water Resources Research Catalog **9**, 8.0123.

303-0353W-860-00

PLANT GROWTH AND WATER USE IN THE NORTHERN PLAINS

See Water Resources Research Catalog **9**, 3.0113.

303-0354W-070-00

FLOW IN POROUS MEDIA IN RELATION TO DRAINAGE DESIGN AND DISPOSAL OF POLLUTANTS

See Water Resources Research Catalog **9**, 8.0122.

303-0355W-820-00

MEASUREMENT, PREDICTION AND CONTROL OF SOIL-WATER MOVEMENT IN ARID SOILS

See Water Resources Research Catalog **9**, 2.0322.

303-0356W-810-00

RUNOFF CONTROL BY MANIPULATION OF SOIL PROPERTIES

See Water Resources Research Catalog **9**, 4.0079.

303-0360W-830-00

TILLAGE, CROP AND RESIDUE PRACTICES FOR CONTROL OF EROSION IN THE NORTHWEST

See Water Resources Research Catalog **8**, 3.0394.

303-0361W-880-00

INTERAGENCY FRAIL LANDS STUDY–MONTANA

See Water Resources Research Catalog **9**, 2.0696.

303-0362W-810-00

EFFECT OF RANGE MANAGEMENT PRACTICES ON SURFACE RUNOFF

See Water Resources Research Catalog **9**, 4.0140.

303-0441W-860-00

INCREASING, CONSERVING, AND MANAGING SURFACE WATER SUPPLIES FOR AGRICULTURAL USE

See Water Resources Research Catalog **11**, 3.0011.

303-0442W-810-00

INFILTRATION, EROSION CONTROL AND SOIL WATER MOVEMENT IN RELATION TO IRRIGATION

See Water Resources Research Catalog **11**, 3.0128.

303-05209-840-00

DEVELOPMENT OF IMPROVED SURFACE IRRIGATION SYSTEMS

(*c*) A. S. Humpherys, Agr. Engr., Snake River Conservation Research Center, Route 1, Box 186, Kimberly, Idaho.

(*d*) Experimental, field investigations; applied research and development.

(*e*) Develop improved surface systems for the control and application of irrigation water. Devices, structures and techniques for manual, semiautomatic and automatic application of irrigation water will be developed to enable more efficient use of farm water supplies and reduce soil erosion and sedimentation. Structures and devices are tested in the laboratory and the field to determine their hydraulic characteristics and to evaluate the design, performance and adaptability to field conditions. Complete systems will be field tested to evaluate their water and labor requirements and ability to control erosion.

(*g*) Automatic, low pressure pipeline valves and the associated controls for surface irrigation have been developed. These are particularly well-suited for use with gated pipe and have been designed for 6-, 8- and 10-inch pipe. The valves operate on water from the pipeline and the battery-powered control units use both mechanical and electrical timers. In addition to being used in conventional gated pipe systems, the valves are being tested in automatic-cutback and multiset furrow irrigation systems to increase water use efficiency and to reduce field runoff and soil loss. Concrete-pipe ditch turnouts are being semi-automated using timers for border irrigation.

(*h*) **Automatic Controls for Surface Irrigation Systems,** A. S. Humpherys, *Proc. IFAC Symp. Automatic Controls for Agriculture*, C-6, pp. 1-16, Comm. Automatic Control, Natl. Res. Council of Canada, Saskatoon, June 18-20, 1974.

Automated Valves for Surface Irrigation Pipelines, A. S. Humpherys, R. L. Stacey, *Proc. Am. Soc. Civ. Eng., J. Irrig. Drain Div.* **101**, IR2, pp. 95-109, *Proc. Paper 11380.*

How to Get the Most Benefit from Plastic Pipe, A. S. Humpherys, *Irrig. Age* **10**, 6, pp. 28, 30 and 32.

An Experimental Buried Multiset Irrigation System, R. V. Worstell, *Trans. ASAE* **19**, 6, pp. 1122-1128.

Cast-In-Place 2-Foot Concrete Trapezoidal Flow Measuring Flumes, A. S. Humpherys, J. A. Bondurant, *USDA Tech. Bull.* (in press).

Energy and Irrigation System Planning, A. S. Humpherys (Contributing Editor), *Irrig. Age* **11**, 7, pp. 73 and 75.

303-09312-840-00

DESIGN AND OPERATION CRITERIA FOR IRRIGATION RETURN FLOW SEDIMENT PONDS

(*c*) James A. Bondurant, Agr. Engr., USDA-ARS-WR, Route 1, Box 186, Kimberly, Idaho 83341.
(*d*) Theoretical and field investigation; applied research.
(*e*) Many irrigation systems have runoff streams which contribute sediment to a receiving stream. The sediment may carry pesticides, herbicides, phosphorus and nitrogen which may contribute to further degradation of receiving streams. Much of this sediment may be trapped in ponds built either for an individual field, farm, or for a project wasteway. The purpose of this study is to develop methods and criteria to use in designing efficient sediment ponds considering flow rates, sediment size, and quality.
(*g*) Sediment ponds have been constructed for study purposes. Trapping efficiencies have ranged from 30 to 90 percent, and was best at higher flows which have a greater concentration of larger particle sizes.
(*h*) **Some Aspects of Sedimentation Pond Design,** J. A. Bondurant, C. E. Brockway, M. J. Brown. Pages C-35-41, In: C. T. Haan (ed.), *Proc. Natl. Symp. Urban Hydrology and Sediment Control*, Univ. Ky., Lexington, July 28-31, *UKY-BU109.*

303-09315-810-00

INFLUENCE OF CLIMATIC, BIOLOGIC, AND PHYSICAL FACTORS ON RANGELAND WATERSHED HYDROLOGY

(*b*) Soil Conservation Service.
(*c*) L. M. Cox, Hydrologist, Northwest Watershed Research Center, P.O. Box 2700, Boise, Idaho.
(*d*) Experimental, applied research.
(*e*) Develop, test, and apply methods for measuring and predicting snow water distribution for continuous and discontinuous (drift) snowpack areas; test and improve snowmelt computation procedures for long-term and short-term (approaching real time) forecast periods. Provide precipitation inputs compatible with watershed modeling requirements. Develop and test watershed models for runoff prediction and stream channel flow conveyance consistent with needs for predicting environmental impact of rangeland management on water quality and supply. Approach will be to correlate with ground truth snowfall computed from dual gage system and photogrammetric analysis. Analyze precipitation network to provide watershed model input and determine whether size can be reduced. Compare snowmelt forecasts from models with action agency forecasts and discuss improvements with agencies. Test watershed models involving runoff production and channel routing procedures using existing data sets and implement appropriate data network changes. Cooperate with State and Federal units in utilization of watershed models to study environmental impact of range uses.
(*g*) Improved instrumentation tested for sensing snow water content and meteorological parameters for improving water supply forecasts.
(*h*) **Nature's Reservoir,** Office of Communications, USDA, Washington, D.C., *Picture Story 293*, Jan. 1976.
A Device for Evaluating the Water Vapor Exchange Between Snow and Air, L. M. Cox, J. F. Zuzel, L. Perkins, *Water Resources Research* **12, 1, p. 22, 1976.**
Optimizing Long-Term Streamflow Forecasts, J. F. Zuzel, D. C. Robertson, W. J. Rawls, *J. Soil and Water Conservation* **30**, 2, pp. 76-78, 1975.
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Snow: Nature's Reservoir, L. M. Cox, W. J. Rawls, J. F. Zuzel, *Water Resources Bulletin* **11**, 5, pp. 1009-1012, 1975.
Relative Importance of Meteorological Variables in Snowmelt, J. F. Zuzel, L. M. Cox, *Water Resources Research* **11**, 1, pp. 174-176, 1975.

303-09316-810-00

INFLUENCE OF BIOLOGIC AND SOIL FACTORS ON RANGELAND WATERSHED HYDROLOGY

(*b*) Bureau of Land Management.
(*c*) C. L. Hanson, Agric. Engr., G. A. Schumaker, Soil Scientist, and G. R. Stephenson, Geologist, Northwest Watershed Research Center, P.O. Box 2700, Boise, Idaho.
(*d*) Experimental, applied research.
(*e*) Investigate evaporative water losses from rangeland watersheds and develop models that describe evapotranspiration from rangeland watersheds. Evaluate the effects of range management practices on the hydrologic cycle and incorporate rangeland watershed data into the development and testing of rangeland hydrology models. Determine the relationships between soil-water changes and the associated rangeland watershed responses. Measure water quality parameters and determine their relationships to snowmelt and rainfall runoff, soil and vegetation characteristics, land use, and topographic and physiographic features. Determine chemical and biologic constituents in channel flow, irrigation return flow, and runoff from small feedlots.
(*g*) Publication of a model for predicting evapotranspiration from native rangelands in the northern Great Plains. A study on sagebrush control has been completed. Water quality studies have found that water quality standards in upland rangelands streams are rarely exceeded; however, in streams along irrigated pastures, where cattle are wintered, fecal coliform standards may be exceeded up to 50 percent of the time.
(*h*) **Model for Predicting Evapotranspiration from Native Rangelands in the Northern Great Plains,** C. L. Hanson, *Trans. of the ASAE* **19**, 3, pp. 471-477, 481, 1976.
Influence of Fertilization and Supplemental Runoff Water on Production and Nitrogen Content of Western Wheatgrass and Smooth Brome, C. L. Hanson, G. A. Schumaker, C. J. Erickson, *J. of Range Management* **29**, 5, pp. 406-409, 1976.

303-09318-830-00

EFFECT OF RUNOFF, PRECIPITATION, CLIMATE, SOIL, VEGETATION, LAND USE AND LAND FORM ON SEDIMENT YIELD

(*b*) Bureau of Land Management.
(*c*) C. W. Johnson, Hydraulic Engineer, Northwest Watershed Research Center, P.O. Box 2700, Boise, Idaho.
(*d*) Experimental, applied research.
(*e*) Measure sediment yield and determine its relationship to snowmelt and rainfall runoff, soil and vegetation characteristics, land use, and topographic and physiographic features. Sediment yields and runoff are measured for important sediment contributing areas. Erosion from hillslopes is determined by topographic surveys and, together with vegetation surveys, climatic and soils information will be used to evaluate the Universal and modified Universal Soil Loss Eqaution. Suspended and bedload samplers are providing data on sediment transport and sediment grainsize during runoff events.
(*g*) Sediment sources and yields are being established for rangeland conditions. Water quality parameters are being measured and correlated with rangeland uses.
(*h*) **Sediment Sources and Yields from Sagebrush Rangeland Watershed,** C. W. Johnson, C. L. Hanson, *Proc. Interagency Sedimentation Conf.*, Denver, Colo., pp. 1-70 to 1-80, 1976.
Idaho Rangeland Watershed Management and Research, C. W. Johnson, V. S. Webb, *Watershed Management Symp., ASCE Irrigation and Drainage Div.*, Logan, Utah, 1975.
Sediment Yield from Southwest Idaho Rangeland Watersheds, C. W. Johnson, G. R. Stephenson, C. L. Hanson, R. L. Engleman, C. E. Englebert, *Paper No. 74-2505, ASAE Ann. Winter Mtg.*, Chicago, Ill., 1974.

303-09319-830-00

SELECTING A COMBINED WATERSHED RUNOFF-SOIL EROSION MODEL FOR THE NONIRRIGATED NORTHWEST

(*b*) Cooperative with University of Idaho Agricultural Experiment Station.
(*c*) Myron Molnau, Agr. Engr. Dept., Buchanan Engrg. Lab., Univ. of Idaho; and D. K. McCool, USDA, ARS, Agr. Engr. Dept., 219 Smith Engr. Bldg., Washington State Univ., Pullman, Wash. 99164.
(*d*) Experimental, theoretical, and field investigations; basic, applied, and developmental research; thesis.
(*e*) Existing watershed runoff models will be examined as to applicability for adequately describing runoff under Pacific Northwest conditions. Each watershed model will be assessed as to input requirements, applicability to small watersheds (10 to 500 acres), snowmelt component modeling, and suitability of outputs for potential erosion models. The potential erosion models will be most critically evaluated as to ability to distinguish between raindrop impact erosion and erosion resulting from overland flow. Promising models will be made operational on a computer and some tests as to adequacy for prediction purposes will be made using available data.
(*g*) A snowmelt model has been developed for the Palouse agricultural area. The model is based on the degree day equation with the melt factor a function of accumulated degree days. Because of the cloudy winters, solar radiation apparently does not play as important a role here as in other areas of the nation. The model is capable of handling up to four watershed zones based primarily on slope and aspect. The new snowmelt model was introduced into the USDAHL-74 watershed model; then the USDAHL-74 model, the Kentucky watershed model, and the TVA API runoff model were all tested with data from Missouri Flat Creek, a 7100-hectare (27.1-sq mile) watershed on the Washington-Idaho border. All three models gave adequate simulation of annual and monthly total runoff even though the TVA model has no snowmelt routine. This is probably because the snowfall is typically high density and mixed with rain. The USDAHL-74 and Kentucky models did well on daily simulation with the USDAHL-74 model slightly better. Comparison of hydrographs is thus far inconclusive.
(*h*) **Simulation of the Snow Hydrology of the Palouse Prairie,** D. L. King, *M.S. Thesis*, Univ. of Idaho, 1976.
Application of Runoff Models to a Palouse Watershed, M. Molnau, K. H. Yoo, *ASAE Paper No. 77-2048*, presented 1977 Summer Mtg. ASAE. Copy of paper can be obtained from first author.

303-09320-830-00

CAUSATIVE FACTORS AND SYSTEMS FOR CONTROL OF EROSION IN THE PACIFIC NORTHWEST DRYLAND GRAIN GROWING REGION

(*b*) Cooperative with Washington State University Agricultural Experiment Station and University of Idaho Agricultural Experiment Station.
(*c*) D. K. McCool and R. I. Papendick, USDA, ARS, 215 Johnson Hall, Washington State Unviersity, Pullman, Wash. 99163.
(*d*) Experimental, theoretical, and field investigations; basic, applied, and developmental research.
(*e*) Use field studies to determine the quantitative effects of climatic influences, physiographic features, soil physical conditions, and agricultural land treatment on water-caused soil erosion. Develop from these data gross empirical models for short-term use in predicting soil loss on Palouse soils. Develop and test, in laboratory and field, combined hydrologic/erosion-sedimentation models to determine their usefulness in assessing the effect on soil erosion of proposed cultural treatments and mechanical systems.
(*g*) A first-generation adaptation of the Wischmeier-Smith or Universal Soil Loss Equation has been developed from field soil loss data. The adaptation includes slope length and steepness relationships different from those used in the midwest as well as climatic hazard factor (equivalent erosion index) that includes the effects of snowmelt runoff. The adapted equation is being used by the Soil Conservation Service in Idaho, Oregon, and Washington on a trial basis. Research is continuing to improve the relationship.
(*h*) **Variation of Suspended Sediment Load in the Palouse Region of the Northwest,** D. K. McCool, R. I. Papendick, presented *1975 Winter Mtg. ASAE.* Copy of paper can be obtained from first author.
The Universal Soil Loss Equation as Adapted to the Pacific Northwest, D. K. McCool, R. I. Papendick, F. L. Brooks, *Proc. 3rd Federal Inter-Agency Sedimentation Conf.*, Sedimentation Committee of the Water Resource Council, 1976.
Recent Developments and Needs for Erosion Research in the Dryland Grain Region of the Pacific Northwest, D. K. McCool, M. Molnau, R. I. Papendick, F. L. Brooks, *Proc. Natl. Soil Erosion Conf., SCSA*, Purdue Univ., W. Lafayette, Ind., 1976.
A Portable Rill Meter for Measuring Soil Loss, D. K. McCool, M. G. Dossett, S. J. Yecha, presented *1976 Summer Mtg. ASAE.* Copy of paper can be obtained from first author.

303-10623-810-00

RUNOFF QUANTITY AND QUALITY FROM PASTURE AND CROPLAND WATERSHEDS IN THE PALOUSE REGION OF WASHINGTON AND IDAHO

(*b*) Partially supported by EPA and cooperative with the Agricultural Experiment Stations of Washington State University and the University of Idaho.
(*c*) K. E. Saxton and D. K. McCool, USDA, ARS, 219 Smith Agricultural Engineering, Washington State University, Pullman, Wash. 99164.
(*d*) Experimental and field investigation; basic and applied research.
(*e*) Several small agricultural watersheds are being studied to determine the hydrology, sedimentation, and water quality as related to agricultural land management. Runoff from a well-managed grazed watershed and an adjacent ungrazed check watershed is being studied for sediment, chemical, and biological characteristics. Similar data from two meadow watersheds will also determine water quality from ungrazed areas. Runoff, sedimentation, and chemical quality are being determined from three cropland watersheds approximately 2, 9, and 27 square miles in size. Crops are primarily winter wheat in rotation with spring wheat, barley, and peas. Tillage ranges from conventional plow-disk to heavy stubble mulch.
(*f*) Recently initiated.
(*g*) No significant results yet available.

303-10624-870-00

NONPOINT POLLUTION CONTROL FOR RANGELAND WINTER LIVESTOCK OPERATIONS

(*b*) Agricultural Experiment Station, University of Idaho.
(*c*) G. R. Stephenson, Geologist, Northwest Watershed Research Center, P.O. Box 2700, Boise, Idaho.
(*d*) Experimental, applied research.
(*e*) Evaluate alternative management practices, and develop guidelines, for the control of waterborne pollutants from cow-calf wintering operations. Sites will be selected along Reynolds Creek in Owyhee County, Idaho; alternate management practices will be established on selected sites. All sites will be instrumental for water sampling, runoff and sediment measuring, and soil moisture and groundwater measurement. Water samples will be analyzed for nitrate, nitrite, phosphorous, sodium, potassium, organic carbon, coliform, fecal streptococci and other constituents including sediment from the evaluation of management practices, guidelines for controlling runoff and potential pollution will be developed.
(*g*) Project still in initiation phase.

303-10625-810-00

DEVELOP METHODS TO PREDICT PRECIPITATION AND RUNOFF FOR BETTER USE AND PROTECTION OF SOIL AND WATER RESOURCES OF SOUTHWESTERN RANGELANDS

(*c*) Herbert B. Osborn, Supr. Hydrologic Engr., USDA, ARS Southwest Watershed Research Center, Tucson, Ariz. 85705.
(*d*) Experimental project based on rainfall and runoff data from semi-arid rangelands in Arizona and New Mexico.
(*e*) Determine statistics of convective rainfall and runoff on experimental watersheds. Develop methods to estimate rainfall patterns and runoff in ephemeral stream channels. Develop models to simulate hydrologic responses of watersheds to predict changes from rangeland restoration or management practices.
(*g*) A rainfall occurrence model for the Southwest has been developed which identifies seven types of rainfall occurrence and assumes probability of occurrence for different locations based on latitudes, longitude, and elevation. The occurrence model is part of a larger model to predict areal rainfall amounts for selected locations. A runoff simulation model was improved by developing procedures to identify runoff source areas. A study on brush to grass conversion of a 110-acre watershed indicted the importance of rainfall character and occurrence on runoff and sediment.
(*h*) **Thunderstorm Runoff in Southeastern Arizona,** H. B. Osborn, E. M. Laursen, *J. Hydr. Div., ASCE* **98,** HY7, pp. 1129–1145, 1973.
Management of Ephemeral Stream Channels, H. B. Osborn, K. G. Renard, *J. Irrigation and Drainage Div., ASCE* **99,** IR3, pp. 207-214, 1973.
Stochastic Models of Spatial and Temporal Distribution of Thunderstorm Rainfall, H. B. Osborn, L. J. Lane, R. S. Kagan, *Proc. Symp. Statistical Hydrology, USDA Misc. Publ. 1275,* pp. 211-231, 1974.
Simplifications of Watershed Geometry Affecting Simulation of Surface Runoff, L. J. Lane, D. A. Woolhiser, *J. Hydrology,* (in press).
Simulation of a Partial Area Response from a Small Semi-Arid Watershed, L. J. Lane, D. E. Wallace, *Hydrology and Water Resources in the Southwest, Proc. AAS-AWRA* **6,** pp. 137-147, 1976.
Precipitation on Intermountain Rangelands in the Western United States, K. G. Renard, D. L. Brakensiek, *Proc. US/Australia Rangeland Workshop,* Boise, Idaho, 1976.
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303-10626-810-00

SEDIMENT SOURCES, TRANSPORT AND PROPERTIES IN SEMI-ARID WATERSHEDS

(*c*) Kenneth G. Renard, Supr. Hydraulic Engr., USDA-ARS Southwest Watershed Research Center, Tucson, Ariz. 85705.
(*d*) Experimental project to improve water erosion predicting and control on semi-arid rangelands.
(*e*) Develop improved methods to predict water and erosion and control to preserve and increase productivity of land and water resources.
(*g*) The Universal Soil Loss Equation (USLE) has been evaluated as a tool for predicting or estimating soil erosion from semi-arid rangelands. Extreme variability in rainfall over short time and distances and nonuniform cover make estimates difficult. Incised channels also add to the uncertainties in adapting the USLE in the Southwest. Runoff simulation models which identify runoff sources areas, and thus simulate partial area response, are being developed to infer sediment sources areas.
(*h*) **Applicability of the Universal Soil Loss Equation to Semi-Arid Rangeland Conditions,** K. G. Renard, J. R. Simanton, H. B. Osborn, *Hydrology and Water Resources in Arizona and the Southwest, Proc. AAS-AWRA* **4,** pp. 18-32, 1974.
Thunderstorm Precipitation Effects on the Rainfall-Erosion Index of the USLE, K. G. Renard, J. R. Simanton, *Hydrology and Water Resources in Arizona and the Southwest, Proc. AAS-AWRA* **5,** pp. 47-57, 1975.
Use of the USLE in the Semi-Arid Southwest, H. B. Osborn, J. R. Simanton, K. G. Renard, *Proc. Erosion Symp.,* Purdue Univ., 1976. *J. Soil and Water Conservation,* (in press).

303-10627-810-00

INCREASED WATER-USE EFFICIENCY IN SEMI-ARID REGIONS FOR GREATER AND STABLER FORAGE

(*c*) Robert M. Dixon, Soil Scientist, USDA, ARS, Southwest Watershed Research Center, Tucson, Ariz. 85705.
(*d*) Experimental project to determine principles and practices for controlling point infiltration and onsite runoff.
(*e*) Develop principle and practices for controlling infiltration and runoff leading to improved forage production.
(*g*) To realize the objective of developing cultural practice for point infiltration control, a new minimum tillage implement, referred to as a land imprinter, has been designed and fabricated, and is being tested. The land imprinter is designed to increase range productivity through more efficient soil and water use. A device for measuring surface microroughness was designed and fabricated, and runoff farming by waxing soils was tested.
(*h*) **Design and Use of Closed-Top Infiltrometers,** R. N. Dixon, *Proc. Soil Science Soc. of America* **39,** 1975.
Water Table Position as Affected by Soil Air Pressure, D. R. Linden, R. M. Dixon, *Water Res. Research, AGU* **11,** 1, pp. 139-143, 1975.
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U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION, Ogden, Utah 84401. Roger R. Bay, Director.

304-06969-810-00

SNOWPACK HYDROLOGY

(*c*) Mr. Harold F. Haupt, Project Leader, Forestry Sciences Laboratory, 1221 South Main, Moscow, Idaho 83843.
(*d*) Field investigation, basic and applied research.
(*e*) Snowpack is being studied in northern Idaho for the applied objective of regulating yield and timing of streamflow. The particular research reported here pertains to improved instrumentation for measuring winter precipitation and estimated potential water yield as affected by slope exposure and early site recovery.
(*h*) The hydrologic response of small clearcuts on north and south slopes in northern Idaho was investigated. On north slope, substantial gains (27 to 35 cm) in potential water yield per year accrued from removal of transpiring surfaces associated with plant cover, elimination of snow interception by a closed-canopied forest, perhaps some airborne movement of snow from the south (windward) to north (lee) slope, and slow reoccupation of the soil mantle by invading plant species. In contrast, on south slope there appeared to be no long-term gain in potential water yield resultant from timber cutting. Small differences in estimated yield between forest and small clearcut were evident in some years; in other years, none. Site factors with compensating effect were the cause. In the south-slope forest, water losses from interception were light because of the open-canopied structure of the timber, whereas in the small clearcut, water gains from reduced transpiration were more than used up by invading shrub species. We conclude that managing for increased water yield may be a valid consideration in the decision to log north but not south slopes similar to those studied.

A simple technique has been found to install soil moisture access tubes in stony or bouldery forest soils with a minimum of site disturbance. The hole for the access tube is made by driving a pointed, machine-tooled driving rod to the depth required with a specially constructed 15 kg king tube hammer. Under good soil conditions, 14 to 16 access tubes can be installed in a day, but when the soil is excessively bouldery, the number is reduced to five to seven. This method has the advantage of requiring substantially less capital outlay, causing less disturbance to surroundings and providing easier access to remote study areas than methods using large heavy equipment, such as tractor-borne hydraulic rams or jackhammers.

(*h*) **Installation of Neutron Probe Access Tubes in Stony and Bouldery Forest Soils,** R. G. Cline, B. L. Jeffers, *Soil Sci.* **120,** pp. 71-72, 1975.

Potential Water Yield Response Following Clearcut Harvesting on North and South Slopes in Northern Idaho, R. G. Cline, H. F. Haupt, G. S. Campbell, *Res. Paper INT-191,* Intermountain Forest and Range Experiment Station, Forest Service, USDA, 16 pages, 1977.

304-08436-810-00

FOREST PRACTICE EFFECTS

(*c*) Mr. Harold F. Haupt, Project Leader, Forestry Sciences Laboratory, P.O. Box 469, 1221 South Main, Moscow, Idaho 83843.

(*d*) Field investigation, basic and applied research.

(*e*) Forest practice studies on the impact of timber harvesting on the quality of stream water are presently in progress at several locations in northern Idaho. The monitoring program has a three-fold objective: to evaluate changes in the physical and chemical quality of stream water on and off clearcut-burned units; to characterize nutrient losses from different drainage patterns; and to determine the effectiveness of buffer strips in controlling sediment and nutrient losses.

(*g*) Leaf diffusive conductant, leaf water potential, and leaf osmotic potential measurements were made on one tree species and three woody brush species on north and south aspects in the Priest River Experimental Forest of northern Idaho. Douglas maple and western white pine occurred on both aspects. Sitka alder and mallow ninebark occurred only on north and south aspects, respectively. Mallow ninebark on the south aspect attained osmotic and leaf water potentials near -30 bars and daytime leaf diffusive conductant (reciprocal of resistance) near 0.3 cm/s. The white pine on the site attained osmotic and leaf water potentials near -25 bars and leaf diffusive conductants near 0.06 cm/s. Osmotic and leaf water potential decreased to a minimum specific to each deciduous species as the season progressed. The alder and maple species exhibited osmotic potentials near -16 bars with the maple leaf water potential decreasing further to near -20 bars. The white pine maintained a uniform osmotic potential between -20 and -25 bars throughout the year. Leaf diffusive conductants appeared to be controlled during the day by a combination of atmospheric demand, soil moisture availability, and plant adaptation to water stress. Stomatal control of leaf water potential was evident in white pine on both aspects and in the brush species on the north but not on the south aspect.

(*h*) **Clearcutting and Burning Slash Alter Quality of Stream Water in Northern Idaho,** G. G. Snyder, H. F. Haupt, G. H. Belt, Jr., *Res. Paper INT-168,* Intermountain Forest and Range Experiment Station, Forest Service, USDA, 34 pages, 1975.

Seasonal and Diurnal Water Relation of Selected Forest Species, R. G. Cline, G. S. Campbell, *Ecology* **57,** 2, pp. 367-373, Spring 1976.

304-09323-830-00

TREE PLANTING FOR EROSION CONTROL ON GRANITIC ROADFILLS IN THE IDAHO BATHOLITH

(*c*) Dr. Walter F. Megahan, Project Leader, Intermountain Forest and Range Experiment Station, 316 E. Myrtle Street, Boise, Idaho 83706.

(*d*) Field investigations, applied research.

(*e*) Road erosion on road fill slopes is a major concern following road construction in the Idaho Batholith. The objectives of the present study were threefold, to measure the reduction in surface erosion following tree planting (ponderosa pine) with and without straw mulch; to provide information on tree survival and growth as affected by mulches, fertilizer, and tree spacing; and to define some of the basic soil erosion processes that are acting on granitic roadfills. The study consists of 30 1/200-acre plots located on a large roadfill; four years of data are presently available for the analysis.

(*f*) Work completed. Data analysis done. Final publication not out.

(*g*) Tree survival averaged about 97 percent for four years. Fertilizer increased tree height growth up to 95 percent during the year of peak effect. Tree planting, coupled with straw mulch and erosion netting, reduced surface erosion about 95 percent. Trees, alone, provided surprisingly large reductions in erosion, ranging from 32 to 51 percent. Daily erosion rates average higher during summer periods as compared to winter periods because of higher energy inputs. Dry creep is an important erosion process that accounts for about 20 percent of the total erosion occurring during summer periods.

(*h*) **Deep-Rooted Plants for Erosion Control on Granitic Road Fills in the Idaho Batholith,** W. E. Megahan, *Res. Paper INT-161,* Intermountain Forest and Range Exp. Sta., Forest Service, USDA, 22 pages, 1974.

304-09324-830-00

EFFECTS OF LOGGING AND ROAD CONSTRUCTION ON STREAM CHANNELS ON FORESTED WATERSHEDS IN THE IDAHO BATHOLITH

(*c*) Dr. Walter F. Megahan, Project Leader, Intermountain Forest and Range Experiment Station, 316 E. Myrtle Street, Boise, Idaho 83706.

(*d*) Field investigation, applied research.

(*e*) First- and second-order drainages in forested areas have the potential for storing considerable sediment because of large volumes of debris in the channel (rocks, logs, etc.). Sediment storage information is required if realistic sediment yield simulation models for forested lands are to be developed. The design includes a detailed network of channel cross sections on seven study watersheds. Numerous data are collected to characterize channel conditions.

(*g*) Four years of data are available for analysis. Sediment storage during a low-flow year amounted to approximately 80 cubic feet per 100 lineal feet of channel (channel widths average about 3-feet wide). During a high-flow year, sediment storage dropped to approximately 40 cubic feet per 100 feet of channel.

(*h*) **Sediment Storage in Channels Draining Small Forested Watersheds in the Mountains of Central Idaho,** W. F. Megahan, R. A. Nowlin, *Proc. 3rd Fed. Interagency Sedimentation Conf.,* Denver, Colo., pp. 4-115 to 4-126, Mar. 1976.

304-09325-810-00

EFFECTS OF CLEARCUT LOGGING AND ROAD CONSTRUCTION ON SUBSURFACE FLOW IN THE IDAHO BATHOLITH

(*c*) Dr. Walter F. Megahan, Project Leader, Intermountain Forest and Range Experiment Station, 316 E. Myrtle Street, Boise, Idaho 83706.

(*d*) Field investigation, applied research.

(*e*) Coarse-textured, relatively shallow soils; steep slopes; granitic bedrock with relatively low hydraulic conductivity;

and large volume water inputs from snowmelt and/or large cyclonic storms are all conducive to the generation of subsurface flow. Road construction often incises the subsurface flow level, transforming subsurface to surface flow. This may interrupt the hydrologic function of the watershed containing the road, and has ecologic implications as well. Two micro-watersheds of 0.8 and 2.4 acres in size have been instrumented. Instrumentation includes a climatic station; snow lysimeters; a network of snow stakes, soil moisture access tubes and piezometers; and surface and subsurface flow measuring apparatus.

(*g*) No overland flow has been measured on either study watershed at any time. Subsurface flows occurred only during periods of large volume water inputs to the soils, and was restricted to the spring snowmelt periods. Maximum instantaneous peak flows have exceeded 20 cubic feet per second per square mile. Flows varied slightly between watersheds, but were vastly different between years. Yearly differences were related to amounts and rates of inflow. A comparison of nearby perennial watersheds suggests that the weathered and fractured granitic bedrock is more hydrologically active than previously thought. Interception of overland flow by roads is considerably greater than the flow generated by overland flow from the road surface itself.

(*h*) **Subsurface Flow Interception by a Logging Road in Mountains of Central Idaho,** W. F. Megahan, *Proc. Symp. Watersheds in Transition*, Amer. Water Resources Assoc. and Colorado State Univ., *Proc. Series No. 14*, pp. 350-356, 1972.

304-09326-810-00

THE EFFECT OF LOGGING AND ROAD CONSTRUCTION ON STREAMFLOW, SEDIMENT PRODUCTION, AND WATER CHEMISTRY IN THE SILVER CREEK STUDY AREA, IDAHO BATHOLITH

(*c*) Dr. Walter F. Megahan, Project Leader, Intermountain Forest and Range Experiment Station, 316 E. Myrtle Street, Boise, Idaho 83706.

(*d*) Long-term laboratory and field investigation; basic research that will lead to prescriptions (practical applications) for land use management. Computer modeling of various land disturbances associated with logging and their off-site (downstream) effects is emphasized.

(*e*) Seven research watersheds treated in the southwestern Idaho Batholith have been monitored for a calibration period up to 15 years, including streamflow–quantity and regimen, sediment yield, water and sediment chemistry, and climate. Logging activities will commence in 1975 on a rigid, predetermined schedule to isolate single and multiple downstream effects of different logging systems (skyline and helicopter), differing cutting intensities (clearcut and select cut), and different attendant disturbances (roads vs. no roads; various slash disposal systems, etc.). The purpose of this project is to quantify off-site disturbances from advanced logging systems for future prediction.

(*g*) Accumulated baseline data on the undisturbed watersheds, including streamflow quantity and regimen; sediment production; water and sediment chemistry; and climatic data.

304-09327-390-00

SLOPE STABILITY OF PHOSPHATE MINE SPOIL DUMPS IN SOUTHEASTERN IDAHO

(*b*) Conducted in cooperation with College of Engineering, Utah State University, Logan, Utah.

(*c*) Mr. Paul E. Packer, Project Leader, Forestry Sciences Laboratory, 860 North 12th East, Logan, Utah 84321.

(*d*) Field and laboratory investigation, design and developmental research.

(*e*) With the development of large earth-moving equipment during the past decade, surface mining has increased very rapidly. Larger depths of overburden are being removed from above the ore mined. This overburden must be placed in spoil dumps, resulting in manmade fills, often involving considerably more cubic yardage than in large earth fill dams. The overburden removal may result in steep cuts to depths of hundreds of feet. In addition, earthen roads with widths comparable to super highways must be built for the heavy equipment to haul out the ore. All of these involve, in some form or another, the design, engineering, and placement of fills. Often these fills are given such cursory attention in the planning and construction phases that serious problems result from mass failures, massive erosion with heavy sediment loads carried by the runoff, and barren landscapes on which vegetation does not reestablish itself for many years–if at all.

Recognizing the existing conditions and potential future problems associated with slope stability of overburdened spoil dumps created during phosphate surface mining in southeastern Idaho, a study was undertaken to define and delineate, in general terms, the design and construction criteria for building spoil dumps in the steep terrain of the phosphate mines in southeastern Idaho which will be stable against massive structural failure and result in minimum surface erosion and movement.

(*g*) In summary, the internal friction angle of the materials tested indicates mass failure of the dump created from the overburden should not be subject to massive failure if placed on slopes of three to one or less, even under relatively adverse pore pressure conditions. If no pore pressures are permitted to develop, the dump fills might even be stable if placed on steeper slopes up to 1.5 to 1. While the structural strength of the material is good (i.e., internal friction angles of 35° and above), it has low permeability and, consequently, is subject to high pore pressure if placed while at or near complete saturation. It will require about a year for pore pressures created in this manner to be dissipated.

The material contains relatively large amounts of silt-size grains, and, consequently, is susceptible to surface erosion. The material is also of the composition making it susceptible to frost action. With frost action loosening the surface material, its erodibility will be particularly great during the time of snowmelt and highest rainfall. The potential for large amounts of erosion during this season is great. Consequently, the slopes of the dump fills should be constructed taking into account the establishment of vegetation and minimization of erosion, as well as stabilizing against mass failure. Flatter slopes will generally be dictated by these latter considerations.

(*h*) **Slope Stability of Overburden Spoil Dumps from Surface Phosphate Mines in Southeastern Idaho,** R. W. Jeppson, R. W. Hill, C. E. Israelson, *Utah Water Res. Lab. Rept. RPWG 140-1*, 69 pages, April 1974.

304-09328-810-00

CHARACTERISTICS OF HIGH-INTENSITY RAINFALL IN THE INTERMOUNTAIN WEST

(*c*) Mr. Paul E. Packer, Project Leader, Forestry Sciences Laboratory, 860 North 12th East, Logan Utah 84321.

(*d*) Field and laboratory investigation, design and developmental research.

(*e*) Basic data for the intrastorm occurrence of high intensity rainfall bursts were obtained from precipitation records on the Davis County Experimental Watershed and the Great Basin Experimental Area. Analyses included intrastorm timing and number of rainfall bursts per storm, distribution of rainfall by increments of storm duration, and relation between depth of total storm rainfall and depth of burst rainfall. In addition, data were presented for four different design storms for storm return periods of 2 and 10 years.

(*f*) Completed.

(*g*) Storm arguments are presented for discontinuing the practice of using an annual series frequency analysis as a design aid for construction of forest roads or other control structures. Forest roads or control structures with an expected life of 25 years or less should be designed with the aid of a partial series frequency analysis of only those storms that contain high intensity rainfall bursts.

(*h*) **Some Intrastorm Characteristics of High Intensity Rainfall Bursts,** E. E. Farmer, J. E. Fletcher, in *Distribution of Precipitation in Mountainous Areas* **2,** *Geilo Symp.*, Norway, pp. 525-531, July 31-Aug. 5, 1972.

304-09329-820-00

ACCURACY OF NEUTRON SOIL MOISTURE MEASUREMENTS

(*c*) Mr. Paul E. Packer, Project Leader, Forestry Sciences Laboratory, 860 North 12th East, Logan, Utah 84321.
(*d*) Applied laboratory research project.
(*e*) The effects of voids on the accuracy of neutron soil moisture measurements in coarse and fine sand were investigated, utilizing two 25-cubic foot plastic tanks. Test voids, three inches and six inches in diameter and 10 inches long, were cut from aluminum tubing and fastened to the neutron access tube in each tank. The difference in neutron measurements between the two tanks with the water at a given level measures the effects of the voids.
(*f*) Completed.
(*g*) A maximum error of +55 percent moisture by volume was caused by the large void in coarse sand with the void saturated; with the void drained, the error was -12.3 percent moisture. Errors in fine sand were slightly less than those in coarse sand; and errors due to the small void were about one-third the magnitude of errors due to the large void. Graphs were developed for use in estimating the size of voids adjacent to access tubes and in calculating the probable magnitude of measurement errors due to these voids when using field data.
(*h*) **Effects of Air Gaps and Saturated Voids on Accuracy of Neutron Moisture Measurements,** B. Z. Richardson, E. R. Burroughs, Jr., *Res. Paper INT-120*, Intermountain Forest and Range Experiment Station, Forest Service, USDA, 1972.

304-09330-810-00

EFFECTS OF LOGGING AND BURNING ON WATERSHED CHARACTERISTICS AND BEHAVIOR

(*c*) Mr. Paul E. Packer, Project Leader, Forestry Sciences Laboratory, 860 North 12th East, Logan, Utah 84321.
(*d*) Applied field investigation.
(*e*) Sixty-five study units, from 10 to 58 acres in size, in the larch and Douglas-fir forest type of western Montana, were clearcut and the logging debris broadcast burned between 1967 and 1970. Multidisciplinary research on these units included the effects of these treatments on soil stability and runoff. Overland flow and sediment were caught in tanks below 24 runoff plots.
(*f*) Continuing. Extended to lodgepole pine type in the West.
(*g*) Logging and burning temporarily impaired watershed protection and increased overland flow and erosion of soils that are derived from Belt series rocks and occur on gentle-to-steep slopes. However, vegetal recovery returned conditions to near prelogging status within four years. The small increase in plant nutrient losses, which occurred in the sediment and the overland flow during the denuded period, represented only a small fraction of the available nutrients on these sites. This strongly indicates that damage to soil and water resources and to the nutrient reservoir on these forest sites as a result of clearcut logging and burning is not serious from the standpoint of future site stability and productivity.
(*h*) **Plant Nutrient and Soil Losses in Overland Flow from Burned Forest Clearcuts,** N. V. DeByle, P. E. Packer, *Symp. on Watersheds in Transition*, *Amer. Water Res. Assoc. and Colorado State Univ. Proc.*, pp. 296-307, 1972.
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304-09331-830-00

INHERENT ERODIBILITY OF IMPORTANT WESTERN MOUNTAIN SOILS

(*c*) Mr. Paul E. Packer, Project Leader, Forestry Sciences Laboratory, 860 North 12th East, Logan, Utah 84321.
(*d*) Applied laboratory and field research.
(*e*) To a large degree, raindrops provide the detaching force that is prerequisite to the transport of soil particles by either flowing water or raindrop splash. Disturbed surface soil masses of three highly erodible soils, two coarse-granitic soils from the Idaho Batholith and one fine-textured clay soil from the Wasatch plateau in central Utah, were subjected to controlled simulated rainfall. The relative detachability of 11 soil-size fractions was determined by comparing the proportion of a given size fraction in the pretreatment soil mass with the proportion of that size fraction in the splashed soil.
(*f*) Completed.
(*g*) Tests were conducted under two levels of rainfall intensity, three degrees of slope steepness, and in the presence or absence of overland flow. Effects of differences in rainfall intensity and slope steepness were small. Overland flow had a pronounced effect in increasing particle detachment resulting from raindrop impact. The highest surface soil detachment hazard occurs in soils having high proportions of medium-sand-size material (particles and aggregates). This includes most of the better mountain soils in the western United States. Because particle detachability does not appear to be strongly affected either by slope steepness or by rainfall intensity, these detachability data probably can be generalized to many mountain slopes.
(*h*) **Relative Detachability of Soil Particles by Simulated Rainfall,** E. E. Farmer, *Proc. Soil Science Society of America* **37,** 4, July-Aug. 1973.

304-10645-820-00

THE EFFECT OF ROAD CONSTRUCTION ON PIEZOMETRIC HEAD IN A TYPICAL IDAHO BATHOLITH SLOPE

(*c*) Dr. Walter F. Megahan, Project Leader, Intermountain Forest and Range Experiment Station, 316 E. Myrtle Street, Boise, Idaho 83706.
(*d*) Field investigation, applied research.
(*e*) A steep, forested slope has been instrumented with a series of piezometers. Two other stations are equipped with nuclear snow water, precipitation, and soil moisture sensing devices and with hygrothermographs. Piezometers were installed in three transects of 18 piezometers each, 2 years prior to road construction and logging. Transects are located up and down the slope and extend for a total distance of about 120 feet. After 2 years of undisturbed measures a road will be constructed through the middle of the transects and the area will be logged. Piezometer transects are located to evaluate the effects of treatment on piezometric head. Measurements will be continued after the disturbance for a 2 to 3-year period.
(*g*) An extremely low snowfall during the winter of 1976-77 resulted in no subsurface flow during the spring runoff period. Measurements in the undisturbed state will be continued for another year.

U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, NORTH CENTRAL FOREST EXPERIMENT STATION, 1992 Folwell Avenue, St. Paul, Minn. 55108. John H. Ohman, Director.

305-03887-810-00

WATERSHED MANAGEMENT RESEARCH IN NORTHERN MINNESOTA

(*c*) D. H. Boelter, USDA, Forest Service, North Central Forest Experiment Station, Grand Rapids, Minn. 55744.
(*d*) Experimental and field investigation; basic and applied research.

(*e*) Use basic hydrologic studies to develop management practices that will maintain or improve the quality and quantity of water yields from northern forest lands. Forest cultural practices (including timber harvesting, fertilization, use of herbicides, and prescribed burning) are studied to determine their effect on the water resources of northern conifer-hardwood forests. Of special concern will be the complex associations of uplands and bogs common to these forests. Methods will be developed for sampling and analyzing both surface and subsurface flows from treated areas. Shallow water impoundments developed for wildlife habitat will be monitored and water level management guidelines developed to maximize desired habitat and minimize any adverse effects on water quality. Peat filter beds used for sewage effluent treatment are being monitored to develop criteria for construction and maintenance which improve their effectiveness and minimize any effects on quality of associated water resources.

(*g*) Complete clearcutting of aspen on the upland portion of an upland-bog watershed did not change the chemical composition of streamflow from the watershed. Total streamflow increased 30 to 50 percent during each of the first five years after cutting, but is expected to return to precutting levels in eight to ten years as new vegetation grows.

Baseline nutrient yield data were obtained for upland-peatland watersheds in north-central Minnesota. Concentrations of organic-derived nutrients are highest in streamflow from watersheds with oligotrophic peatlands; while concentrations of nutrients derived from acquifer minerals were higher in streamflow from watersheds with minerothrophic peatland.

A peat filter bed used to treat sewage effluent at a recreational campsite was monitored for three years. Annual total nitrogen and total phosphorus renovation efficiency ranged from 61.3 percent to 87.3 percent and 99.1 percent to 99.6 percent, respectively. Total coliform reduction was in excess of 99.9 percent each year.

(*h*) **An Electro-Optical Temperature Controller for Maintaining a Constant or Relative Temperature,** J. M. Brown, *Agron. J.* **67,** pp. 280-281, 1975.

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305-09332-870-00

SEWAGE DISPOSAL ON FOREST AND ASSOCIATED LANDS

(*b*) Some aspects of project are in cooperation with Michigan Department of Natural Resources.

(*c*) Dean H. Urie, USDA, Forest Service, North Central Forest Experiment Station, Stephen Nisbet Building, 1407 S. Harrison Road, East Lansing, Mich. 48823.

(*d*) Field investigations, basic and applied research.

(*e*) Research is conducted on the environmental impact of application of municipal and industrial sewage wastes to forest lands. Studies are primarily concerned with nitrate pollution hazards to groundwater under irrigation of natural and planted short rotation forest types, under irrigation with sewage lagoon effluents and with municipal and pulp and paper sewage sludges. An associated problem is the field and laboratory investigation of the use of sewage sludge for rehabilitation of acid strip-mine spoil. Continuing studies include investigations on the effects of different size sediment loads (primarily sand bedloads) on trout populations, development of techniques to reduce bedload, and effects of strip-cutting and clearcutting conifer plantations on groundwater yields and snowpack accumulation.

(*g*) Five years of sewage effluent irrigation of forests have shown that nitrogen is the principal hazard to groundwater quality. After three years of irrigation a 23-year-old red pine plantation leached a relatively constant proportion of added N to groundwater, ranging from about 10 percent at 25 mm per week to about 30 percent at 88 mm per week. During the fourth year of growth hybrid poplars leached NO_3-N at approximately the same rate as pines on similar soils. A cotton wood hybrid showed the best survival and growth of all tree varieties and species tested under irrigation. Major impacts on stream morphology occurred following four years of daily sand sediment accretions to a brook-trout test area.

Sewage sludge amelioration of acid strip-mine spoil has reduced concentrations of metals in leachate. Nitrate leaching from sludge sources reached a 4 foot depth within 12 months under greenhouse conditions.

Campground sewage injected into a sandy forest soil resulted in slight (< 10 ppm) increases in nitrate-N in groundwater at 3 m depths. Herbaceous vegetation incorporated about 40 percent of the added nitrogen during the first growing season.

(*h*) **Effect of an Artificially Increased Sand Bed Load on Stream Morphology and Its Implications on Fish Habitat,** E. A. Hansen, G. R. Alexander, *Proc. 3rd Federal Interagency Sedimentation Conf.*, Sed. Committee of Water Res. Council, pp. 3-65 to 3-76, 1976.

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U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION, P.O. Box 3141, Portland, Oreg. 97208. Robert F. Tarrant, Director.

306-04757-810-00

WATER YIELD AND EROSION, WENATCHEE, WASHINGTON

(*c*) Dr. A. R. Tiedemann, Project Leader.
(*d*) Field investigations; basic and applied research.
(*e*) Generate information necessary to develop prescriptions which improve or enhance quantity and timing of water yield without decreasing water quality; reduce erosion and restore land stability and productivity; and rehabilitate deteriorated sites in the mid-Columbia River Basin forests of eastern Oregon and Washington. Studies related to erosion reduction include characteristics of soil related to erodibility; effects of climate, vegetation and parent material on soil development, soil movement such as creep or mass movement, characteristics of forest humus types; and physical control of erosion by increasing plant density of vegetation. Studies related to water quantity and quality include changes in volume and timing of runoff, water chemistry and water temperature following timber harvest, wildfire or defoliation by insects; changes in wind patterns, soil moisture use, and snow accumulation and melt following common silvicultural practices; and water use rates by common tree species within the study area.
(*g*) Debris torrents following high intensity rainstorms on fire-denuded watersheds in north-central Washington during 1972 have been summarized by location soil type, topography, and land use history.

The results of erosion protection seeding and fertilization were evaluated on watersheds of the Entiat Experimental Forest, Washington. Average vegetative cover increased from 8.6 percent the first year following fire to 31 percent at the end of 4 years.

Differences between the autumnal soil-water deficit in the upper 120 cm of the soil profile of the Entiat Experimental Forest were estimated to be 11.6 cm one year after vegetation removal by wildfire. This increase in soil water had a significant influence on streamflow.

A new type of recording instrument for long-term monitoring of the role of wind in snow accumulation has been developed and patented.

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U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, PACIFIC SOUTHWEST FOREST AND RANGE EXPERIMENT STATION, P.O. Box 245, 1960 Addison Street, Berkeley, Calif. 94701. Robert Z. Callaham, Director.

307-04996-810-00

WATER YIELD IMPROVEMENT, CONIFER ZONE

(*b*) Cooperative with U.S. Bureau Reclamation, National Aeronautics and Space Administration and Univ. California.
(*c*) Dr. James L. Smith, Project Leader, Water Yield Improvement, Conifer Zone.
(*d*) Experimental; field investigation; basic and applied research.
(*e*) Determine the relationships which exist between the climate and the snowpacks of the Sierra Nevada, and how these relationships are affected by the presence or absence of forest cover, so that the effect of forest cultural practices upon snow metamorphism and melt may be predicted in advance of application of such practices. Present studies emphasize study of snow density changes, water holding capacities, snow metamporphism and melt rates under a variety of meteorological and cover conditions, and the effect of these changes upon timing of delivery of water to streams. Determine effect of evaporation suppressants upon reduction of water losses from snowpacks under a variety of aspect-cover conditions. Determine effect of weather modification upon snowpacks of Central Sierra Nevada of California.
(*g*) Study of snowpacks under open and forested conditions shows that forest cover or its lack drastically affects both water holding capacity of snowpacks and delivery rate and pattern to the streams, either via the soil under the pack or through the snow, downslope over ice lenses. A manual is being prepared which land managers may use to plan harvests to accomplish desired objectives.

Analysis of snowpacks and simulation of potential snowpacks resulting from weather modification indicate that in the "warm" Sierra Nevada snow augmentation will only increase time snow remains on the land from 0 to 14 days.

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307-04998-810-00

PARAMETERS AFFECTING MANAGEMENT OF FORESTS ON UNSTABLE LANDS

(*b*) Cooperative with California Div. of Forestry and Humboldt State University.

(*c*) Dr. Raymond M. Rice, Project Leader, Pacific Southwest Forest and Range Experiment Station, 1700 Bayview Drive, Arcata, Calif. 95521.

(*d*) Experimental; field investigations; basic and applied research.

(*e*) The Unit's mission is to gain an understanding of the hydrological and biological processes of the ecosystems of the north coast and Klamath Mountains of northern California and southern Oregon; and to develop information needed for integrated resource management consistent with protecting the resources and environment on unstable lands. Studies underway are aimed at developing methods for evaluating potential watershed damages from logging and road building, achieving rapid regeneration to insure the recovery of slope stability, appraising the impact of logging and road building on anadromous fish habitats, and devising strategies for optimum monitoring of various nonpoint source pollutants.

(*g*) An analysis has been completed relating site variables to the occurrence of debris avalanches on granitic terrain. Based on interpretation of 1:6000 aerial photographs, it revealed that the most cost effective equation for estimating landslide hazard was based on only three variables: slope, crown cover by overstory vegetation, and ground cover by understory vegetation. A linear discriminant function based upon those variables correctly classified about 80 percent of the 235 sites used in the analysis. Analysis of 13 years of flood peaks from two experimental watersheds has confirmed that logging has a negligible effect on important flood events. Roads had been constructed in one of the watersheds and it had been selectively harvested over a 3 year period. The road construction was associated with no discernible change in flood runoff. During and following logging there were dramatic increases (over 300 percent) in small, mainly early season, peaks but no change in large winter runoff events. Preliminary investigations suggest that subsurface hydrology of logged areas may be chemically disturbed as a result of timber harvest. Phenolic compounds, which are some of the early decay products of wood, have been shown in laboratory tests to disperse clays. If operable in the field, this phenomenon might cause reduced hydraulic conductivity at critical layers in the soil profile. An analysis of 102 harvest areas in northwestern California has shown that when tractors are restricted to gentle slopes, erosion is greatly reduced but soil disturbance only moderately reduced. In an area where tractor yarding was only conducted on slopes less than 30 percent erosion on tractor cut blocks was one-fifth of that on similar, steeper, cable yarded cutblocks, but soil disturbance was still 4 times greater. In another area where a slope limitation was not in effect tractor areas had 7 times the disturbance and 9 times the erosion of similar cable yarded areas.

(*h*) **Forest Management to Minimize Landslide Risk,** R. M. Rice, reprinted from *Guidelines for Watershed Management, FAO Conservation Guide*, Rome, pp. 271-287, 1977.

307-04999-810-00

MANAGEMENT OF CHAPARRAL AND RELATED ECOSYSTEMS IN SOUTHERN CALIFORNIA

(*b*) Cooperative with California Div. of Forestry.

(*c*) C. Eugene Conrad, Project Leader, Pacific Southwest Forest and Range Expmt. Sta., 110 North Wabash Ave., Glendora, Calif. 91740.

(*d*) Experimental; field investigations; basic and applied research.

(*e*) To help solve the multi-functional problem facing managers on chaparral lands through an integrated, multi-discipline research approach. To gain understanding of the complex interrelationships between fire, water and vegetation in these environments and the effects of watershed, recreation, wildlife, and fire management practices on multiple-use land management goals. To develop enough information and techniques to produce management guidelines for chaparral and related ecosystems.

(*f*) Discontinued: Flood and Sediment Reduction from Steep Unstable Brushland of the Southwest.

(*g*) Water repellency affects the flow of water in unsaturated soil and decreases both infiltration and evaporation. Diffusivity analyses suggest that water repellency has the greatest effect at lower levels of soil water and the effect diminishes as water content increases toward saturation. Flow across the particle surfaces seems to be affected most by water repellency. Several water flow equations, containing a term for the wetting angle between water and the particle surface, have been used to quantify the various degrees of water repellency. Measurements of wetting heat suggest that vapor flow may be an important water flow mechanism at lower soil water contents.

(*h*) **Mechanical Methods of Chaparral Modification,** G. A. Roby, L. R. Green, *U.S. Dept. Agric., Agric. Handbk. 487*, 46 pages, illus. 1976.

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307-09335-810-00

FOREST AND WATERSHED RESOURCE MANAGEMENT RESEARCH IN HAWAII AND OTHER PACIFIC ISLAND AREAS

(*b*) Cooperative with Hawaii Department of Land and Natural Resources and University of Hawaii.
(*c*) Roger G. Skolmen, Project Leader, Timber and Watershed Management Research in Hawaii.
(*d*) Experimental; field investigations; basic and applied research.
(*e*) Research on effects of land use on watershed hydrology; effects of vegetation types on soil hydrology; stream sediment relationships to watershed vegetation cover; and water infiltration measurement systems.
(*g*) Water infiltration capacities are significantly greater for soils under forest cover than under cultivation or grazing.
(*h*) **Forests and Water: Some Questions Answered,** R. A. Merriam, *Aloha Aina*, pp. 12-14, illus., Jan. 1971.
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U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION, 240 W. Prospect Street, Fort Collins, Colo. 80521.

308-02658-810-00

WATER YIELD IN THE BLACK HILLS

(*c*) Ardell J. Bjugstad, Project Leader, Forest Research Laboratory, South Dakota School of Mines and Technology.
(*d*) Experimental; basic and applied research.
(*e*) Determine geologic, geomorphic, and forest factors that influence or relate to quantity and timing of the water yield and reclamation of surface mine spoils.
(*h*) **Reestablishment of Woody Plants on Mine Spoils and Management of Mine Water Impoundments: An Overview of Forest Service Research on the Northern High Plains,** A. J. Bjugstad, in *Reclamation of Disturbed Arid Lands Symposium*, 1776 Mass. Ave. NW, Washington, D.C., Amer. Assoc. for the Advancement of Science, 1977.
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308-03569-810-00

WATERSHED MANAGEMENT RESEARCH, LARAMIE, WYOMING

(*b*) Bureau of Land Management; Wyoming Highway Department.
(*c*) Ronald D. Tabler, Project Leader.
(*d*) Field investigation; applied research.
(*e*) Water yield characteristics of big-sagebrush lands are being studied on plots and gaged watersheds, and hydrologic effects of control measures are being determined. Methods for increasing snow accumulation in windswept areas are also being developed and tested.
(*h*) **Hydrologic Relations on Undisturbed and Converted Big Sagebrush Lands: The Status of Our Knowledge,** D. L. Sturges, *USDA For. Serv. Res. Paper RM-140*, 23 pages, 1975.
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308-09338-810-00

MULTI-RESOURCE MANAGEMENT OF SUBALPINE CONIFEROUS FORESTS, FORT COLLINS, COLORADO

(*c*) Robert R. Alexander, Project Leader.
(*d*) Experimental, field investigations, basic and applied research.
(*e*) Develop systems for integrating available and newly developed information into decision-making tools for land management and planning, and predict the effects of vegetation manipulation on water yield and quality.
(*h*) **More Water from Mountain Watersheds,** C. F. Leaf, *Colorado Rancher* **28**, 7, pp. 11-12, 1974.
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308-09339-810-00

WATERSHED REHABILITATION TO CONTROL EROSION AND SEDIMENTATION IN THE SOUTHWEST, ALBUQUERQUE, NEW MEXICO

(*c*) Earl F. Aldon, Project Leader.
(*d*) Experimental, field investigations, applied research.
(*e*) See Water Resources Research Catalog.
(*f*) Discontinued.
(*h*) **Influences of a Forest on the Hydraulic Geometry of Two Mountain Streams,** B. H. Heede, *Water Resour. Bull.* **8**, pp. 523-530, 1972.

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308-10646-880-00

MINE SPOIL RECLAMATION IN THE SOUTWEST, ALBUQUERQUE, NEW MEXICO

(*b*) U.S. Department of Agriculture, Forest Servie, Rocky Mountain Forest and Range Experiment Station.
(*c*) Earl F. Aldon, Project Leader.
(*d*) Experimental, field investigation, applied research.
(*e*) Research has been directed specifically toward: Identify plant materials adaptable to coal mine spoil environments, develop seeding and planting methods, devise means to augment water available for plant growth, design spoil banks to maximize stability, limit runoff, and enhance cover development.
(*h*) **Revegetating Coal Mine Spoils in New Mexico: A Laboratory Study,** E. F. Aldon, H. W. Springfield, *USDA For. Serv. Res. Note RM-245*, Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo., 4 pages, 1973.

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Using Paraffin and Polythylene to Harvest Water for Growing Shrubs, E. F. Aldon, H. W. Springfield, *Proc. Water Harvesting Symp.*, Phoenix, Ariz., Mar. 26-28, 1974, USDA, *Agric. Res. Serv. ARS w-22*, pp. 251-257, 1975.

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308-10647-810-00

MULTIRESOURCE RESPONSE EVALUATION OF MANAGEMENT ALTERNATIVES FOR MIXED CONIFER, CHAPARRAL, AND MOUNTAIN GRASSLAND WATERSHEDS OF THE SOUTHWEST (FS-RM-1606)

(*c*) Leonard F. DeBano, Project Leader, Forestry Sciences Laboratory, Arizona State University Campus, Tempe, Ariz. 85281.
(*d*) Experimental; field investigations; basic and applied research.
(*e*) Research is being conducted to determine responses by watersheds to management alternatives and evaluate impacts on associated resource values in chaparral, mixed conifer forests, and mountain grasslands; develop methodology and procedures for predicting water-resource reactions to comprehensive land management programs.
(*h*) **Chaparral Conversion Potential in Arizona. Part I., Water Yield Response and Effects on Other Resources,** A. R. Hibbert, *USDA For. Serv. Res. Paper RM-126*, 36 pages, 1974.

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Energy Budget Measurements Over Three Cover Types in Eastern Arizona, J. R. Thompson, *Water Resources Research* **10**, 5, pp. 1045-1048, 1974.

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308-10648-810-00

SNOWDRIFT MANAGEMENT AND AVALANCHE HAZARD EVALUATION

(*b*) Colorado State University.
(*c*) M. Martinelli, Jr., Project Leader.
(*d*) Experimental and field investigation; applied research.
(*e*) Determine methods for predicting and controlling the transport and deposition of the snow by winds in order to modify natural drift patterns for managerial purposes. Improve the evaluation and forecasting of avalanche hazard to reduce the danger from snow avalanches in ski areas, mountain highways, mining operations and mountain home sites.
(*g*) Electronic snow particle counter has been modified to give mass flux of blowing snow. A real-time avalanche warning program has been operational for western Colorado for the past several winters. A quantitative orographic precipitation model has been developed and tested for western Colorado. A numerical hydrological model of avalanche motion has been developed and is being tested.
(*h*) **Predicting Avalanche Intensity From Weather Data: A Statistical Analysis,** A. Judson, B. J. Erickson, *USDA For. Serv. Res. Pap. RM-112*, 12 pages, 1973.

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U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, SOUTHEASTERN FOREST EXPERIMENT STATION, P.O. Box 2570, Asheville, N. C. 28802. J. B. Hilmon, Director.

309-0247W-810-00

IMPROVEMENT OF WATER QUALITY AND YIELD, SOUTHERN APPALACHIANS-PIEDMONT

For summary, see Water Resources Research Catalog **9**, 3.0262.

U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, SOUTHERN FOREST EXPERIMENT STATION, T-10210 Postal Services Building, 701 Loyola Avenue, New Orleans, La. 70113. Laurence E. Lassen, Director.

310-06973-810-00

MULTI-RESOURCE MANAGEMENT OF FORESTS IN THE OZARK-OUACHITA HIGHLANDS

(*b*) Cooperative with the University of Arkansas.
(*d*) Field investigations; applied research.
(*e*) To formulate forest management alternatives to enhance values of water, timber and related forest resources. Hydrologic research is aimed at determining the effects of various silvicultural measures on streamflow and water quality. Measurement of hydrologic responses from partial and complete vegetation removal on three small watersheds in the Quachita Mountains has been completed. Hydrologic responses to planting pine and natural regeneration on these watersheds are now being studied. Calibration of three watersheds in the Springfield Plateau has been completed and the effects of two silvicultural treatments are to be investigated. Calibration of four watersheds in the Boston Mountains is being continued. Soil water, surface runoff, sediment losses and nutrient losses via runoff are being monitored on all watersheds.
(*g*) Results indicate significant increases in soil water and runoff following partial and complete vegetation removal from the Ouachita Watersheds. Sediment losses increased immediately after timber removal, but returned to pretreatment levels in three years. Herbicide residues in runoff were detected in only one of three years and they were minimal and of short duration. Diameter growth of shortleaf pine was significantly increased as a result of understory removal and thinning the pine overstory. Soil water deficits in northern Arkansas were significantly different on forested and clearcut areas, but were no different on northwest and southeast aspects. Growing season deficits on forested areas were over four times those on cut areas. Spring deficits were very similar under both cover conditions.
(*h*) **2,4,5-T Residues in Storm Runoff from Small Watersheds,** E. R. Lawson, *J. Soil & Water Conserv.* **31,** 5, pp. 217-219, 1976.
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Soil Water Deficits Under Forested and Clearcut Areas in Northern Arkansas, T. L. Rogerson, *Soil Sci. Soc. Am. J.* **40,** 5, pp. 802-805, 1976.

310-06974-810-00

HYDROLOGIC EVALUATION OF FOREST MANAGEMENT ALTERNATIVES FOR THE SOUTHERN COASTAL PLAIN PINERY

(*c*) Stanley J. Ursic, Project Leader, U.S. Forest Service, Forest Hydrology Laboratory, P.O. Box 947, Oxford, Miss. 38655.
(*d*) Field investigation; applied research.
(*e*) See Water Resources Research Catalog **11**, 4.0126 and 5.0969.

DEPARTMENT OF THE ARMY, U.S. ARMY BALLISTIC RESEARCH LABORATORY, Aberdeen Proving Ground, Md. 21005. Dr. Robert J. Eichelberger, Director.

311-09355-010-00

FLOW FIELD PERTURBATIONS CAUSED BY PROTUBERANCES IN BOUNDARY LAYERS

(*c*) Dr. Raymond Sedney, Launch and Flight Division, R. H. Kent Bldg.
(*d*) Theoretical and experimental applied research.
(*e*) Experimental flow visualization methods were developed and used to study the local changes to a smooth surface boundary layer caused by a three-dimensional protuberance. Physical models of the near flow field are constructed. The Navier-Stokes equations are solved numerically for a two-dimensional square protuberance in Couette flow.
(*f*) Completed.
(*g*) The optical-surface indicator technique, developed in this task, has been used to resolve the details of the multiple flow separations and reattachments which occur in the flow field near a protuberance immersed in a supersonic turbulent boundary layer. We find that the number and size of vortices formed in the separated flow region are dependent on the Reynolds number. We have visualized the flow off the surface using a laser-illuminated vapor screen technique. Flow separation and reattachment near square two-dimensional protuberances have been studied numerically using the full Navier-Stokes equations.
(*h*) **The Structure of 3-D Separated Flows in Obstacle-Boundary Layer Interactions,** R. Sedney, C. W. Kitchens, Jr., *AGARD-NATO Symp. Flow Separation*, Göttingen, Federal Republic of Germany, May 1975, *AGARD Conference Preprint 168.*
The Role of the Zone of Dependence Concept in Three-Dimensional Boundary-Layer Calculations, C. W. Kitchens, Jr., R. Sedney, N. Gerber, *Proc. AIAA 2nd Computational Fluid Dynamics Conf.*, Hartford, Conn., pp. 102-112, June 1975.

311-09356-010-00

THREE-DIMENSIONAL BOUNDARY LAYERS

(*c*) Dr. Clarence W. Kitchens, Jr., Launch and Flight Division, R. H. Kent Bldg.
(*d*) Numerical and theoretical applied research.
(*e*) The role of the zone of dependence concept in three-dimensional boundary-layer calculations is investigated. This concept is especially important for calculating the boundary layer over a spinning body at incidence. A new exact solution which simulates the essential features of the complex flow over a spinning body is used as a test case to test four finite-difference schemes. The stability properties of the finite-difference equations are being studied.
(*g*) A new exact solution is developed and used as a test case. Two new finite-difference schemes for three-dimensional boundary layers are developed. Four finite-difference schemes are tested to determine the effect of violating the zone of dependence rule. We show that error growth results from violating this rule in numerical computations; however, the two new schemes are shown to be fairly insensitive to these violations. We show that stability restrictions and the zone of dependence rule are not the same.
(*h*) **The Role of the Zone of Dependence Concept in Three-Dimensional Boundary-Layer Calculations,** C. W. Kitchens, Jr., R. Sedney, N. Gerber, *Proc. AIAA 2nd Computational Fluid Dynamics Conf.*, Hartford, Conn., pp. 102-112, June 1975.

311-09357-540-00

SPIN-UP IN A LIQUID-FILLED SHELL

(*c*) Dr. Raymond Sedney, Launch and Flight Division, R. H. Kent Bldg.
(*d*) Theoretical investigation, applied research.

(*e*) Investigation of instabilities occurring early in the flight of liquid-filled shells gives rise to the task of determining the unsteady flow of the liquid in a shell impulsively spun up from rest. An approximate model (E. H. Wedemeyer) has led to a single partial differential equation for the flow in a completely-filled shell with a cylindrical cavity. Here an economical, efficient and accurate numerical technique has been developed and applied to this spin-up equation. The program is set up for three "Ekman suction compatibility" conditions: 1) linear, laminar; 2) linear, turbulent; 3) Rogers and Lance, laminar. The program also integrates the velocity profiles to provide the angular momentum history of the fluid.

(*g*) Numerical solutions have been obtained for wide ranges of the parameters of the problem (dimensions of the cavity, kinematic viscosity and spin rate), providing a complete picture of the effects of the parameters on the velocity profiles. Comparison with analytical approximations show the conditions under which the latter are valid.

(*h*) **Properties of Rigidly Rotating Liquids in Closed, Partially-Filled Cylinders,** *J. Applied Mechanics* **42,** 3, Sept. 1975.

DEPARTMENT OF THE ARMY, COASTAL ENGINEERING RESEARCH CENTER, CORPS OF ENGINEERS, Kingman Building, Fort Belvoir, Va. 22060. John H. Cousins, Colonel, CE, Commander and Director.

312-02193-490-00

COASTAL CONSTRUCTION–DEVELOP FUNCTIONAL/STRUCTURAL DESIGN CRITERIA

(*c*) R. A. Jachowski, Chief, Design Branch, Engrg. Development Division.

(*d*) Applied research and engineering design development.

(*e*) Development of functional and structural design criteria is directed at summarizing for design application, information obtained through research by the Corps and others, compiling and synthesizing it, and finally translating it into a form directly usable by coastal engineers, and in a sense, is the end product of all CERC's research.

(*g*) An interim report was prepared on a steel pile corrosion study at Dam Neck, Virginia. A final report has been prepared on the stability of sand-filled nylon bag breakwater structures. Work has been carried out on the reanalysis of wave runup on structures and beaches, and a final report and two coastal design memoranda have been prepared. A coastal design memorandum was also prepared which reorganized material previously published on wave set-up on a sloping beach. Work has continued on preparation of the Coastal Engineering Manual.

(*h*) **Shore Protection Manual, 2nd Edition, Vols. I, II, III,** U.S. Army, Corps of Engineers, Coastal Engineering Research Center, Stock No. 008-022-00077-1, U.S. Government Printing Office, Washington, D.C., 1,160 pages, 1973.

Evaluation and Development of Water Wave Theories for Engineering Application R. G. Dean, *Special Rept. No. 1*, (2 Volumes), U.S. Government Printing Office, Washington, D.C., Nov. 1974.

Small-Craft Harbors: Design, Construction, and Operation, J. W. Dunham, A. A. Finn, *Special Rept. No. 2*, U.S. Government Printing Office, Washington D.C., Dec. 1974.

312-02195-430-00

EVALUATION OF SHORE PROTECTION STRUCTURES

(*c*) D. W. Berg, Chief, Evaluation Branch, Engineering Development Division.

(*d*) Field investigation; applied research.

(*e*) Evaluation of Shore Protection Structures is directed at providing improved functional design criteria for coastal projects through analysis of the behavior of selected prototype structures which have been built. Current design practice depends on many empirical relationships and coefficients that are generally based on insufficient data. By evaluating structure performance, techniques which have been obtained through empirical or analytical efforts can be confirmed, and the accuracy of coefficients determined. Data are collected before, during and after construction of shore structures, including repetitive surveys, material sampling, littoral forces (to the extent possible), and the techniques and materials of construction. Analysis of these data is aided by the use of electronic data processing techniques.

(*g*) Data processing continued for the following locations: Hampton Beach, N. H.–beach fill and nourishment; Wallis Sands Beach, N. H.–beach fill and terminal groin; Suffolk County, L. I., N. Y.–groin system; Carolina Beach Inlet, N. C.–dredging of throat of unimproved inlet; Carolina Beach, N. C.–beach fill, dunes, and nourishment; Wrightsville Beach, N. C.–beach fill, dunes, and nourishment from littoral reservoir at experimental weir-type jetty; Hunting Island, S. C.–beach fill and nourishment.

312-06995-880-00

COASTAL ECOLOGICAL STUDIES

(*c*) R. M. Yancey, Ecology Branch, Research Division.

(*d*) Field investigations; applied research.

(*e*) Six work units representing ecological problem areas are under study. Three are concerned with vegetation and three others with animals.

(*g*) The work units are listed as follows:

Foredune Ecology: To define and evaluate the impacts of foredune construction upon the biotic communities of the beach and landward areas of barrier islands including adjacent shallow water areas of lagoons and sounds and to develop predictive models for use in planning.

Bank Erosion Control With Vegetation: To provide a natural, inexpensive, efficient method of bank erosion protection by use of living plants in areas of relatively low wave energy.

Ecological Effects of Beach Nourishment: To define and quantify the ecological effects of beach nourishment operations in southern California, middle U.S., Atlantic and Florida Gulf coastal areas and make that information available for planning and management purposes; to provide beach nourishment guidelines that adequately consider the effects of initial obtention (i.e. dredging) of beach fill material, and the effect of sand emplacement on the living resources of the operations area such as clam beds of commercial or recreational value and other animals in the sandy bottom or attached to nearby hard surfaces. While long-term effects of sand emplacement were considered, only the ecological effects of borrow pit creation are considered in this work unit (see separate work unit for long term effects of borrow pits).

Ecological Effects of Rubble Structures: To define and quantify the ecological effects of rubble mound structures in three U.S. coastal areas.

Effects of Construction and Operation of Field Research Facility: To define, quantify and document the ecological effects of the construction and initial operation of the CERC research pier on the biota of Currituck Banks, N.C.

Productivity of Western Salt Marshes: To obtain primary productivity information, compare the information with western marsh productivity and evaluate the productivity of western marshes.

(*h*) **Ocean Waste Dumping Operations Monitoring,** Anonymous, Sperry Systems Management Div., AD735378, Sperry Rand Corp., 1971.

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Propagation of *Sparina alterniflora* **for Substrate Stabilization and Salt Marsh Development,** W. W. Woodhouse, Jr., E. D. Seneca, S. W. Broome, *CERC Tech. Memo. No. 46*, Aug. 1974.

312-09733-410-00

BEACH PROFILE STUDIES

(*c*) Allen DeWall, Coastal Processes Branch, Research Division.
(*d*) Field investigation; applied research.
(*e*) Develop criteria for the design of protective sand beaches, and a predictive model that will provide early warning of potentially dangerous beach depletion. The primary source of data is repetitive surveys of beach profile lines at selected coastal localities. This profile data is correlated with environmental factors such as wave, tide, storm and sand conditions, to the extent that they are known, and with engineering works, such as beach fills and groins.
(*g*) Results to date include a report on the residence time and longshore travel of beach fill obtained from the data on Atlantic City and the use of this data in more specific problems at certain localities.
(*h*) **Beach Profile Changes on Western Long Island,** C. H. Everts, *Coastal Geomorpho. Symp.*, Sept. 1972.
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Sand Level Changes on Torrey Pines Beach, California, C. E. Nordstorm, D. L. Inman, Final Report, Aug. 1974.
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Magnitude of Changes on Three New Jersey Beaches, C. H. Everts, A. E. DeWall, M. T. Czerniak, AAPG/SEPM, Apr. 1974.
Beach Changes Caused by the Atlantic Coast Storm of 17 December 1970, A. E. Dewall, P. C. Pritchett, C. J. Galvin, *CERC TP 77-1*, Jan. 1977.
Beach Changes over the Period of a Tidal Cycle, C. H. Everts, GSA, Sept. 1976.
Variations in Beach Erosion and Accretion Trends at Virginia Beach, Va. and Vicinity, V. Goldsmith, S. C. Sturm, G. R. Thomas, Final Rept., Mar. 1977.

312-09735-470-00

ALASKA HARBOR RESEARCH (SEDIMENTATION IN HIGH TIDE RANGE AREAS)

(*c*) Dr. Craig Everts, Chief, Geotechnical Engineering Branch, Engineering Development Division.
(*d*) Field investigation; applied research.
(*e*) Prediction of shoaling rates for Alaskan harbors prior to their construction, the application of this knowledge to siting harbors in areas of least shoaling, and improved guidelines for harbor design. Field data from Nushagak Bay, Kenai and Knik Arm, Alaska, have been collected. Included are data on sediment concentration, sediment

size distribution and density; water salinity and temperature; water current velocity, wave characteristics, ice tidal elevations, estuary bathymetry, tidal flat topography, tidal flat sediment characteristics and time changes in tidal flat surface elevation. Shoaling rates have been measured in a sedimentation test facility and in a prototype Alaskan half-tide harbor. The resulting data are being analyzed and techniques to predict shoaling rates will be developed. Work on harbor siting continues.

(*g*) Results to date include a better understanding of the factors contributing to shoaling in Alaskan Harbors.

(*h*) **Shoaling Rates and Related Data from Knik Arm Near Anchorage, Alaska,** C. H. Everts, H. Moore, *Coastal Engeg. Research Center Tech. Paper 76-1*, 84 pages.
Tidal Flat Accretion in Alaska, H. Moore, C. H. Everts, *Trans. Amer. Geophys. Union* **54,** 4, 1973.
Sediment Discharge by Two Glacial Melt-Water Streams in Alaska, C. H. Everts, *Trans. Amer. Geophys. Union* **55,** 4, 1974.
Shoaling Rate Prediction Using a Sedimentation Tank, C. H. Everts, *Proc. Specialty Conf. Civil Engrg. In the Oceans II*, pp. 294-312, June 1975.
Sedimentation in a Half-Tide Harbor, Assessment of the Arctic Marine Environment, C. H. Everts, *Selected Topics*, Univ. of Alaska, pp. 131-160, 1976.
Sediment Discharge by Glacier-Fed Rivers in Alaska, C. H. Everts, *Proc. Symp. Inland Waterways for Navigation Flood Control and Water Diversions*, ASCE, pp. 907-923, 1976.

312-09736-410-00

SEAWARD LIMIT OF EFFECTIVE SEDIMENT TRANSPORT

(*c*) R. J. Hallermeier, Coastal Processes Branch, Research Division.

(*d*) Experimental and theoretical basic and applied research.

(*e*) To define, in operational terms, a zone seaward of which wave-induced sediment transport can be considered negligible for coastal engineering purposes. The seaward and landward edges of this zone will be established in laboratory investigations of sediment-hydraulic interactions. Tests in a prototype-scale oscillating-flow water tunnel at the National Bureau of Standards will define conditions for incipient sand motion and for ripple development. Suspended sediment measurements in CERC laboratory wave facilities will define conditions for significant sediment entrainment from a sand lab.

(*g*) Using four quartz sands and various flow periods between 3 and 15 sec. a series of water-tunnel tests is presently investigating the initiation of sand motion and of ripples, and the height and length of ripples as they grow to equilibrium with the flow. A CERC report on the test results will be published in 1977.
Office study investigated a hypothetical dimensionless parameter indicating if wave energy density is large enough to elevate fine sand a significant distance above the bed. This parameter can be used to calculate the maximum water depth for entrained sand in linear wave of a certain height and period; calculated depths agree with measured depth over the shelf frequently cut into a plane sand shape by constant laboratory wave action. A CERC report in preparation documents these results and proposes a procedure to calculate a yearly limit depth to the active beach.
Planned laboratory tests will investigate entrained sand offshore of the breaker zone, using the Iowa Sediment Concentration Measuring System. Results will be integrated with previous findings from contracted research at University of Iowa and with other reported results.

(*h*) **Investigation of the Operating Characteristics of Iowa Sediment Concentration Measuring System,** F. A. Locher, J. R. Glover, T. Nakato, *Tech. Paper No. 76-6*, U.S. Army Coastal Engrg. Research Center, 99 pages, 1976.
A Positive Displacement Oscillatory Water Tunnel, K. E. B. Lofquist, *Misc. Rept. No. 77-1*, Coastal Engrg. Research Center, 26 pages, 1977.
Wave Entrainment of Sediment from Rippled Beds, T. Nakato, F. A. Locher, J. R. Glover, J. F. Kennedy, *J. Waterway, Port, Coastal and Ocean Div., ASCE* **103,** WW1, *Proc. Paper 12736*, pp. 83-99, 1977.
Calculating a Yearly Limit Depth to the Active Beach, R. J. Hallermeier, to be published as a *CERC Technical Paper*, about 30 pages, 1977.

312-09737-700-00

DESIGN, ASSEMBLY, AND TESTING OF NEW RAPID SEDIMENT ANALYZER

(*c*) C. W. Judge, Chief Petrology Laboratory, Research Support Division.

(*d*) Applied research and development.

(*e*) The project designed and tested improved methods for determining particle diameters in the sand size range (1 mm to 63 microns) based upon fall velocity through a 1.5 meter column of water 15 cm in diameter. Mass and wall effects are reduced by the larger tube and increased sensitivity; the longer tube provides good separation of the coarse sands. Use of a suspended pan and electrobalance for measuring the accumulated fall was investigated and found to have significant oscillatory problems. Output from the rapid sediment analyzer system is provided to a computer system for computation of size class distribution and statistical parameters.

(*g*) The initial system has been built and tested. Alternate methods (such as pressure transducers) of measuring the accumulated fall versus time are being investigated.

312-09742-440-00

EFFECTS OF LONG-TERM GREAT LAKES WATER LEVEL CHANGES

(*c*) William A. Birkemeir, Coastal Processes Branch, Research Division.

(*d*) Field and office investigation; applied research.

(*e*) Evaluation of beach effects especially bluff recession resulting from the current high lake levels and the prediction of probable beach changes that will occur during future episodes of high lake level. Field surveys of 17 profile lines along the eastern coast of Lake Michigan were made at four-week intervals between 1970 and 1974. These data have been correlated with environmental factors such as lake level, wave conditions and foreshore and backshore sand samples. In addition semiannual aerial photographs of 5 miles of the Berrin County, Michigan shoreline are being studied to evaluate the temporal and alongshore variations in the shore and bluff lines between 1970 and 1974.

(*g*) Results to date include several reports that point out that bluff recession is highly variable along the shoreline and that the largest changes occur during late fall and early spring.

(*h*) **Beach Profile Changes: Eastern Lake Michigan, 1970-1973,** R. A. Davis, W. C. Fingleton, P. C. Pritchett, *CERC MP 10-75*, 97 pages, Oct. 1975.
Coastal Changes, Eastern Lake Michigan, 1970-1973, R. A. Davis, *CERC T. P. 76-16*, 64 pages, Oct. 1976.

312-09743-410-00

LITTORAL TRANSPORT TESTING PROCEDURES

(*c*) Charles B. Chesnutt, Coastal Processes Branch, Research Division.

(*d*) Experimental, basic research.

(*e*) Reduce unwanted laboratory effects in movable-bed models and research experiments of wave action on sandy beaches and to develop scale relationships for such models and experiments.
Tests in CERC's wave tanks and basins will include: (1) Laboratory effects studies: (a) two-dimensional tests to empirically identify the magnitude of water temperature and tank length effects by testing extreme conditions, and then, if important, by systematically testing intermediate conditions; and (b) three-dimensional tests to evaluate dif-

fraction, refraction, and reflection effects; and (2) Scale effects studies: (a) two-dimensional tests to empirically evaluate the performance of different sediments in predicting profile shape and simulating onshore/offshore transport; and (b) three-dimensional tests to empirically evaluate techniques for simulating longshore transport and three-dimensional beach changes.

(*g*) The major conclusions drawn from the three lengthy experiments in **Laboratory Effects in Coastal Movable-Beds Models** were:

(1) The shoreline recession rate, averaged over the first 50 hours of the two experiments where the initial slope was the same, but the distance from the generator to the shoreline and the water temperature were different, varied from 0.03 ft/hr to 0.10 ft/hr. This indicates that initial test length may be an important variable affecting rates of profile change.

(2) Important differences in profile development and final profile shapes in the two experiments where initial test length was the same and the initial slope and water temperature were different indicates that the initial slope may be an important variable affecting profile change.

(3) The evidence on the effect of water temperature supports the hypothesis that colder, more viscous water will transport more sediment. The modeler should be aware of possible effects which could result from not maintaining a constant water temperature.

(4) Modelers should be cautious in determining "equilibrium" conditions.

Major conclusions drawn from the paper **Tests on the Equilibrium Profiles of Model Beaches and the Effects of Grain Shape and Size Distribution** and *CERC TP 76-11* were:

(1) The use of model materials which have strongly bimodal or very narrow unimodal size distributions should be avoided.

(2) The use of model materials which have smooth spherical grain shapes should be avoided.

(3) Noda's model law apparently predicts only the foreshore shape and its general use in predicting beach shape and shoreline movement is not recommended.

(*h*) **Laboratory Effects in Coastal Movable-Bed Models,** C. B. Chesnutt, *Proc. Symp. Modeling Techniques*, pp. 945-961, 1975.

Tests on the Equilibrium Profiles of Model Beaches and the Effects of Grain Shape and Size Distribution, J. I. Collins, C. B. Chesnutt, *Proc. Symp. Modeling Techniques*, pp. 907-926, 1975.

Grain Shape and Size Distribution Effects on Coastal Models, J. I. Collins, C. B. Chesnutt, *TP 76-11*, Coastal Engrg. Research Center, July 1976.

312-09744-410-00

CHECKLIST FOR LONGSHORE TRANSPORT PREDICTION

(*c*) Philip Vitale, Hydraulic Engineer, Research Division.

(*d*) Experimental; development.

(*e*) Develop a checklist for computing longshore transport rates to be used by engineers in Corps Districts and Divisions. Laboratory, field and office procedures will be used to evaluate existing methods for the prediction of longshore transport rates. Laboratory and field procedures will be used to test critical questions and office studies will be used to document and evaluate methods. Particular items include documentation of the existing longshore energy flux method; laboratory tests to compare energy flux with longshore force as a predictor of transport rates; evaluation of the relative importance of suspended sediment in contributing to total longshore transport rate; preparation of a recommended check list for longshore transport rate prediction. Each of these four items would be accompanied by a report documenting the results obtained.

(*h*) **Longshore Sediment Transport Rates: A Compilation of Data,** M. M. Das, *Coastal Engrg. Res. Center MP 1-71*, Sept. 1971.

Suspended Sediment and Longshore Sediment Transport Data Review, M. M. Das, *13th Intl. Conf. Coastal Engrg.*, Chap. 54, pp. 1027-1048, 1973.

Longshore Transport of Suspended Sediment, J. C. Fairchild, *13th Intl. Conf. Coastal Engrg.*, Chap. 56, pp. 1069-1088, 1973.

A Gross Longshore Transport Rate Formula, C. J. Galvin, *13th Intl. Conf. Coast. Engrg.*, Chap. 50, pp. 953-970, 1973.

Longshore Energy Flux, Longshore Force, and Longshore Sediment Transport, C. J. Galvin, *EOS, Trans. AGU* **54**, p. 334, Apr. 1973.

Longshore Transport Prediction–SPM 1973 Equation, C. J. Galvin, P. Vitale, *15th Conf. Costal Engrg.*, July 1976.

312-09745-430-00

PROTOTYPE EXPERIMENTAL GROIN

(*c*) D. W. Berg, Chief, Evaluation Branch, Engineering Development Division.

(*d*) Experimental field investigation; applied research.

(*e*) The prototype experimental groin study investigates various configurations. The objectives of the study are to determine the manner in which a groin functions to entrap sand; to determine the effect of groin dimensions and shape on the volume of entrapped sand; and, to determine the manner in which sand moves over, around, or through a groin. To accomplish the above objectives entails measurements of the littoral factors such as beach and nearshore underwater geometry, wave climatology, beach and nearshore underwater bottom sediment characteristics. The resulting relationships will be published and made available to interested organizations for use in the functional design of groins and groin systems.

(*g*) A pier was built at Pt. Mugu, California, in 1969 by the Coastal Engineering Research Center. Using the pier as a work platform and supporting structure, two groins have been installed and tested. The first groin configuration was long, high and impermeable; the second was short, low and impermeable. Both of the groins influenced the shoreline and offshore depths for a distance, in the downcoast direction, equal to about three times the effective length of the groin and in the up coast direction for a distance equal to about five times the effective length of the groin.

During 1974, Phase I a low, short, permeable groin configuration was installed. The permeability was achieved by skipping every third piling in a sheet pile wall. In April 1975, Phase II, a second steel sheet piling wall was added, the missing pile was staggered with respect to Phase I, November 1975, Phase III, the third piling wall was installed, the missing pile was similar to Phase I. As of April 1976 no visible effect on the shoreline either upcoast or downcoast could be observed, the field experiment was terminated 30 June 1976. The analysis continues.

312-09746-410-00

BEACH FILL SEDIMENT CRITERIA

(*c*) R. D. Hobson, Geotechnical Engineering Branch.

(*d*) Applied research involving theoretical and field investigations.

(*e*) Provide guidelines for District use in scheduling optimum available material for beach fills and determine amount of material required. To obtain and analyze field and model data in order to improve the characterization of littoral materials as guidance for specifying, in BEC studies those materials which will provide a more stable beach considering slope, wave, and current regime of a particular coastal sector. Information will be summarized in form of charts and tables suitable for engineers in planning, design, construction, and maintenance of beaches. To attain objectives, investigation includes collection of data related to temporal and spatial changes in beach and offshore profiles, as well as beach and offshore sediment characteristics; additionally, temporal modifications to the profile and sediment at beach nourishment/fill/bypass operations will be monitored. Data obtained will be analyzed and information incorporated into conceptual and mathematical models for interaction to subsequent field data collection programs. Field data from the Atlantic, Gulf, Pacific, and Great Lakes will be obtained. Because a large number of sediment samples will need to be analyzed investigation of temporal and spatial variability of sediment textural properties will be examined in order to assess sampling error, measurement error, information loss through data processing so as to improve the quality of sediment textural data collected by and stored at CERC and used as prime data base for this work unit.

(*g*) Mathematical models have been developed to predict average requirements and renourishment needs by comparing composite granulometric properties of native beach and borrow source sediments. Effects of sediment handling techniques or model predictions are also being investigated. Field studies, including monitoring the performance of selected projects, are being conducted to test the models.

(*h*) **Techniques in Evaluating Suitability of Borrow Material for Beach Nourishment,** W. R. James, *CERC TM* **60,** 1975.
Review of Design Elements For Beachfill Evaluation, R. D. Hobson, *CERC Tech. Publ.* (in press), 1977.

312-09747-710-00

COASTAL IMAGERY DATA BANK

(*c*) D. W. Berg, Chief, Evaluation Branch, Engrg. Development Division.
(*d*) Field investigation, operational development.
(*e*) Proposed project is to index available controlled aerial photography of coastal and estuarine areas of the United States.
(*g*) The indexing as described in (e) above is done on a U.S. Army Corps of Engineers District area basis. Indexing for the following Engineer Districts is complete: NAB, SAN, NPS, NPP, SPN, SAJ, NAO, SAW, NAP, NCB, NCE, NCC, NCS, NAN, SAM, and LMN.
(*h*) **Coastal Imagery Data Bank,** A. Z. Szuwalski, *Interim Rept.*, Nov. 1972.

312-09750-410-00

GREAT LAKES INLET STUDIES

(*c*) R. M. Sorensen, Chief, Coastal Structures Branch, Research Division.
(*d*) Field investigation; applied research.
(*e*) Reversing currents in inlets along the Great Lakes are generated primarily by resonant response to long wave seiching modes of the lakes rather than by the tide. In order to investigate the nature of long wave excitation and the generating mechanism for significant inlet velocities, to establish techniques for predicting inlet-harbor system response, and to develop base data for future planning and design studies, field measurements were conducted in 1974-75 at nine harbors on the Great Lakes. Data collected includes continuous harbor water level measurements at all sites, inlet velocity measurements at the primary site (Pentwater, Michigan), and channel hydrographic surveys at the sites where more recent data were needed. Historic water level and velocity data for some of the harbor sites was also used.
(*f*) Completed.
(*g*) Amplified harbor response and generation of the highest inlet channel velocities is caused by a coupling of the inlet/bay Helmholtz resonance mode with low amplitude (<0.2 ft) high frequency modes of oscillation of the Great Lakes. Typical resonance periods were between 1 and 3 hours. Cumulative frequency velocity distributions were developed for the inlets studied. A spatially integrated numerical model developed for inlet hydraulic analysis was applied to several of the study sites and found effective in predicting the hydraulic response of the inlet/bay systems.
(*h*) **Hydraulics of Great Lakes Inlet–Harbor Systems,** R. M. Sorensen, W. N. Seelig, *Proc. 15th Conf. Coastal Engrg.*, Honolulu, July 1976.
Hydraulics of Great Lakes Inlets, W. N. Seelig, R. M. Sorensen, *Tech. Memo.*, U.S. Army Coastal Engrg. Research Center, 1977.

312-09751-410-00

GENERAL INVESTIGATION OF TIDAL INLETS

(*c*) R. M. Sorensen, Chief, Coastal Structures Branch, Research Division.
(*d*) Experimental; theoretical, and field; applied research and development.
(*e*) Determine the effects of wave action, tidal flow, and related forces on inlet stability and on the hydraulic, geometric, and sedimentary characteristics of tidal inlets; to develop the knowledge necessary for design of effective navigation improvements and new inlets; to evaluate the water transfer and flushing capability of tidal inlets; and to define the processes controlling inlet stability.
(*g*) An office study is being conducted to classify inlets on the basis of their geometry, hydraulics, and stability. The hydraulic characteristics of a number of idealized inlet configurations are being defined through the use of a fixed bed model. An evaluation of physical and mathematical modeling capabilities for prediction of inlet hydraulics is being conducted, as well as an evaluation of the state-of-the-art of inlet movable bed modeling. Field data from a number of inlets are being collected and analyzed to define the significant processes controlling the dynamics and hydraulics of tidal inlets.
(*h*) The reports listed below have been published and are available from NTIS:
Catalog of Tidal Inlet Aerial Photography, J. H. Barwis, June 1975.
Tidal Prism–Inlet Area Relationships, J. T. Jarrett, Mar. 1976.
Annotated Bibliography on the Geologic, Hydraulic, and Engineering Aspects of Tidal Inlets, J. H. Barwis, Jan. 1976.
Notes on Tidal Inlets on Sandy Shores, M. P. O'Brien, Mar. 1976.
Model Materials Evaluation, Sand Tests, E. C. McNair, June 1976.
Hydraulics and Dynamics of New Corpus Christi Pass, Texas; A Case History 1972-73, E. W. Behrens, R. L. Watson, C. Mason, Jan. 1977.
Hydraulics and Dynamics of New Corpus Christi Pass, Texas; A Case History 1973-75, R. L. Watson, E. W. Behrens, Sept. 1976.
Hydraulics and Dynamics of North Inlet, S.C. 1974-75, R. J. Finlet, Sept. 1976.

312-09752-410-00

CHANNEL ISLANDS LONGSHORE TRANSPORT STUDY

(*c*) D. W. Berg, Chief, Evaluation Branch, Engrg. Development Division.
(*d*) Field investigation, applied research.
(*e*) Data including repetitive surveys, sand samples and wave climatology are collected at the Channel Islands Sand Trap area. The purpose is to determine an empirical relationship between longshore energy flux and longshore material transport.
(*g*) A preliminary analysis of the recently acquired data indicated that (transport versus energy flux) points plot above the existing (Shore Protection Manual) relationship. This relationship is a reasonable approximation to the actual relationship. A new integrated survey system technique is being tested at the study site. This system computes horizontal positioning of the survey vessel, sounding depth and transmits the data via radio to a shore based office. At the shore based office the incoming data is processed in real time by a mini-computer and stored on magnetic tape for processing immediately upon completion

of the survey. This system allows the survey vessel to be guided along a preselected course by plotting the position of the vessel on a scope which is located in the shore based office.

(*h*) **Longshore Transport At a Total Littoral Barrier,** R. O. Bruno, C. G. Gable, presented *15th Intl. Conf. Coastal Engrg.*, July 1976.

312-09754-430-00

FLOATING BREAKWATERS

(*c*) D. Lee Harris, Chief, Oceanography Branch, Research Division.

(*d*) Applied research involving both theory and field investigations.

(*e*) The floating breakwater at Friday Harbor, Washington, has been instrumented to measure the wave attenuation, breakwater motion and anchor chain stresses. A theoretical model for the breakwater performance is being developed. Actual performance and theoretical performance will be compared. Work is being performed by the University of Washington.

(*f*) Completed.

(*h*) **Floating Breakwater Field Assessment Program, Friday Harbor, Washington,** B. H. Adee, E. P. Richey, D. R. Christensen, *CERC TP 76-17*, Oct. 1976.

312-09756-420-00

STORM SURGE CALCULATIONS

(*c*) V. M. Hubertz, Oceanography Branch, Research Division.

(*d*) Theoretical and experimental applied research.

(*e*) A two-dimensional numerical storm surge model, previously used for Galveston Bay, is being modified for use for the Charleston estuary and will later be generalized for use with any estuary. Wind fields are obtained from the National Weather Service.

An open coast hurricane model such as SPLASH II, or the Wanstrath Reid model is combined with the estuary model to obtain storm surge predictions for estuaries. The model will be used to estimate the maximum water levels in the estuary for specified return periods.

(*h*) **Storm Surge Simulation in Transformed Coordinates, Volume I Theory and Application,** J. J. Wanstrath, R. E. Whitaker, et al., *Tech. Rept. No. 76-3*, Nov. 1976.

312-09757-420-00

WAVE RUNUP AND OVERTOPPING

(*c*) R. M. Sorensen, Chief, Coastal Structures Branch, Research Division.

(*d*) Experimental, applied research.

(*e*) Produce design curves relating the runup and overtopping of a spectrum of waves on a variety of structures to the basic characteristics of the structures and wave conditions. Testing will be conducted in wave tanks using both monochromatic and irregular waves. The testing will use structures having a variety of slopes, both plane and compound, and surface roughnesses. The runup of monochromatic and irregular waves will be related to make the large amount of existing runup data for monochromatic waves more useful for actual design conditions. The study will produce prediction methods for runup and overtopping that are based on observable or predictable characteristics of real waves.

(*g*) Techniques have been developed to predict irregular wave runup and overtopping rates using existing monochromatic wave data. These techniques are intended to provide interim guidance for the design of coastal structures until the results of the laboratory study are available.

(*h*) **Prediction of Irregular Wave Runup,** J. P. Ahrens, *Coastal Design Memo.* (in publication), U.S. Army Coastal Engrg. Research Center.

Prediction of Irregular Wave Overtopping, J. P. Ahrens, *Coastal Design Memo.* (in preparation), U.S. Army Coastal Engrg. Research Center.

312-09758-420-00

WAVE REFLECTION FROM AND TRANSMISSION THROUGH POROUS STRUCTURES

(*c*) R. M. Sorensen, Chief, Coastal Structures Branch, Research Division.

(*d*) Experimental and theoretical; applied research.

(*e*) Develop a direct analytical method for predicting the wave reflection and transmission characteristics of trapezoidal, multilayered rubble mound structures. This development was accomplished through a two-year contract with Dr. O. S. Madsen at MIT.

(*f*) Completed.

(*g*) The method mentioned in part (e) was developed. First an analytical procedure for determining the reflection and transmission characteristics of homogeneous rectangular crib-style breakwaters was developed. Then an analytical-empirical procedure for evaluating the rate of energy dissipation on a rough inclined impermeable slope was developed. These two procedures are then synthesized to develop the final procedure for predicting the reflection and transmission characteristics of an equivalent trapezoidal porous rubblemount structure.

(*h*) **Energy Dissipation on a Rough Slope,** O. S. Madsen, S. M. White, *J. Waterways Harbors and Coastal Engrg. Div.*, ASCE, Feb. 1976.

Reflection and Transmission Characteristics of Porous Rubble-Mound Breakwaters, O. S. Madsen, S. M. White, *Misc. Rept. 76-5*, U.S. Army Coastal Engrg. Research Center, Ft. Belvoir, Va., 138 pages, Mar. 1976.

Wave Transmission Through Trapezoidal Breakwaters, O. S. Madsen, S. M. White, *Proc. 15th Conf. Coastal Engrg.*, Honolulu, July 1976.

312-09759-420-00

LABORATORY MODELING OF OCEAN WAVES

(*c*) D. C. Esteva, Ocenography Branch, Research Division.

(*d*) Theoretical and experimental; applied research.

(*e*) An algorithm modeled on that used for the analysis of tide records will be used to develop the response function for a programmable wave generator. This response function will be used to develop the input to a mini-computer which will control a hydraulic wave generator to produce desired wave spectra in laboratory wave tanks.

312-09761-410-00

INNER CONTINENTAL SHELF SEDIMENT CHARACTERISTICS

(*c*) S. J. Williams, Geotechnical Engineering Branch.

(*d*) Applied research involving field investigations.

(*e*) To determine the characteristics and extent of materials combining the bottom and subbottom of the inner continental shelf in the zone shoreward of approximately the 120-foot (35 meter) depth contour for purposes of identifying those materials or deposits for beach fill or periodic nourishment, other needs, and relationships of sediment characteristics to regional geomorphology. To attain objectives, investigation includes collection of geophysical data (e.g. bottom and subbottom acoustical energy responses) and nominal 20-foot (6 meter) long cores of the subbottom material. These data are analyzed to determine sediment characteristics and areal extent of sand suitable for beach restoration or periodic nourishment purposes; collected data are also analyzed to better understand the sedimentation and regional geomorphology of the coastal segment under study. Because constraints for obtaining borrow material for beach fill purposes located inland or in backshore coastal zones are becoming more rigid, there is a need to perform the ICONS study along the entire Atlantic, Gulf, Pacific, and Great Lakes coast.

(*g*) Studies of the U.S. inner continental shelf, conducted to date along most of the Atlantic coast and along the coast of southern California, have delineated nearly ten billion cubic yards of sand suitable for beach restoration projects. Additional field programs are planned for Lake Michigan in 1975.

(*h*) **Construction in the Coastal Zone–A Potential Use of Waste Materials,** S. J. Williams, D. B. Duane, *Marine Geology* **18,** 1, pp. 1-15, Jan. 1975, *CERC Reprint 2-75, AD No. A009388.*
Neogene Sediments of Atlantic Inner Continental Shelf Off Northern Florida, E. P. Meisburger, M. E. Field, *Amer. Assoc. Petroleum Geologists Bull.* **60,** 11, pp. 2019-2037, Nov. 1976.
Sedimentation and Ocean Engineering: Placer Mineral Resources, D. B. Duane, *Marine Sediment Transport and Environmental Management*, ed. D. J. Stanley, D. J. P. Surft, pp. 535-556, 1976.
Sedimentation and Coastal Engineering: Beaches and Harbors, D. B. Duane, *Marine Sediment Transport and Environmental Management*, ed. D. J. Stanley, D. J. P. Surft, pp. 493-517, 1975.
Post-Pleistocene History of the U.S. Inner Continental Shelf: Significance to Origin of Barrier Islands, M. E. Field, D. B. Duane, *Geological Soc. America Bull.* **87,** pp. 691-702, May 1976.
Geomorphology and Sediments of Western Massachusetts Bay, E. P. Meisburger, *CERC Tech. Paper 76-3*, 78 pages, Apr. 1976.
Geomorphology, Shallow Subbottom Structure and Sediments of the Atlantic Inner Continental Shelf Off Long Island, New York, S. J. Williams, *CERC Tech. Paper 76-2*, 123 pages, Mar. 1976.
Geomorphology, Shallow Structure and Sediments of the Florida Inner Continental Shelf, Cape Canaveral to Georgia, E. P. Meisburger, M. E. Field, *CERC Tech. Memo.* **54,** 119 pages.
Anthropogenic Filling of the Hudson River (Shelf) Channel, S. J. Williams, **3,** 10, pp. 597-600, Oct. 1975.

312-09762-410-00

DATA COLLECTION OF LITTORAL MATERIALS AND FORCES

(*c*) D. W. Berg, Chief, Evaluation Branch, Engrg. Development Division.
(*d*) Field investigation; applied research.
(*e*) Volunteer personnel use Littoral Environment Observation (LEO) techniques to measure basic forces and response elements in the nearshore beach zone. At each site daily observations are made of breaking wave height, period, and direction, type or character of breakers, longshore current velocity, wind speed and direction, foreshore slope, and rip current and cusp spacing. Monthly sand samples are analyzed to provide beach sediment characteristics. Dry beach profiles are made weekly. Where possible a multitude of sites are established in cooperative efforts (between State and local agencies and the local Corps of Engineers District Office), which continue daily data collection for several years. Computer compatible formated data are processed, collated and studied for long-term characteristics and trends. In addition to LEO other data collection efforts for the Texas Gulf Coast, Lake Michigan, northern and southern coast of California, and coast of Hawaii Corps of Engineers District have been involved in procurance of profile data, sand samples, wave data, and aerial photography. Objective is to procure and develop data that will be of use in planning and designing coastal projects.
(*g*) Cooperative LEO data collection efforts have been or are continued in the following coastal regions: southern California (8 sites, active), northern California (25 sites, inactive), Michigan (25 sites, active), Wisconsin, Indiana, Illinois (15 sites, active), Texas (5 sites, active pilot program). Individual research efforts are not discouraged and volunteer efforts have been or are continued in Massachusetts, Virginia, North Carolina, Florida, Texas, Southern California, Pennsylvania, and Hawaii. Other data collection in Texas, Lake Michigan, northern and southern California, and Hawaii has been terminated and final reports are in preparation by Corps District Offices following completion of data analysis.
(*h*) **Analysis and Interpretation of Littoral Environment Observation (LEO) and Profile Data Along the Western Panhandle Coast of Florida,** J. H. Balsillie, *Tech. Memo. 49*, Coastal Engrg. Res. Ctr., Mar. 1975.
Surf Observations and Longshore Current Prediction, J. H. Balsillie, (in preparation), Coastal Engrg. Res. Ctr., 1974.
Systematic Collection of Beach Data, D. W. Berg, *Proc. 11th Conf. Coastal Engrg., ASCE*, Chap. 17, pp. 273-297, 1969.
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Los Angeles District, Corps of Engineers, Los Angeles, California, U.S. Army, *Beach Erosion Control Report, Cooperative Research and Data Collection Program of Coast of Southern California, Cape San Martin to Mexican Boundary*, 1969.
Los Angeles District, Corps of Engineers, Los Angeles, California, U.S. Army Cooperative Research and Data Collection Program, Coast of Southern California, three-year report, 1967-1969, 1970.

312-10649-420-00

SURF ZONE WAVE STATISTICS

(*c*) Michael G. Mattie, Physicist, Coastal Oceanography Branch, Research Division.
(*d*) Field investigation, applied research.
(*e*) An array of wave gages will be analyzed statistically to determine wave statistics at the gaging points, the change in these statistics along the pier, and the relation of these statistics to a gage in deeper water at the end of the pier. Data will be used to evaluate theoretical concepts of the modification of waves in shallow water, and their transformation into surf and through the surf zone. This work will provide a description of the statistics in the surf zone and the relation of these statistics to those normally available for engineering design.

312-10650-700-00

RADAR IMAGING OF WAVES

(*c*) Michael G. Mattie, Physicist, Coastal Oceanography Branch, Research Division.
(*d*) Field investigation, development.
(*e*) Determine the feasibility of collecting wave direction information with a ground based radar. A commercially available X band marine radar has been procured for a system to image waves in coastal areas. The PPI scope presentation is photographed and the photos are later interpreted to provide wave direction information. The system is automated so that a climatology of wave direction can be obtained.
(*g*) A Decca radar on loan from the Coast Guard has been tested at Cape Cod, Maine, and good images of waves were obtained on the PPI. Comparison of a pressure wave gage data with wave lengths measured on the radar pictures shows good agreement. A Raytheon Mariners Pathfinder Radar has been purchased and installed in an automated radar wave imaging system. This system has been used to collect useful data at Channel Islands Harbor, Calif., and at San Diego, Calif., as part of the West Coast Experiment which was conducted in March 1977 in preparation for the SEASAT launch.

312-10651-420-00

WAVE DATA ANALYSIS TECHNIQUES FOR DESIGN

(*c*) E. F. Thompson, Hydraulic Engineer, Research Division.
(*d*) Investigation of field data; applied research.
(*e*) Field wave measurements will be used to tabulate occurrences of hazardous individual wave conditions during a variety of sea states and to develop general characteristics and probabilities of hazardous conditions. New analysis procedures which can identify two or more distinct wave trains without presenting the full complexity of the wave spectrum and which provide more information about wave shape than can be obtained from wave spectra will be developed. The usefulness of the developed procedures will be evaluated.
(*h*) **The Use of Aerial Photography in the Study of Wave Characteristics in the Coastal Zone,** C. M. McClenan, D. L. Harris, *TM-48*, Jan. 1975.
Wave Characteristics as Revealed by Aerial Photography, C. M. McClenan, D. L. Harris, *OTC 2423*, 1975.
Simplified Method for Estimating Refraction and Shoaling Effects on Ocean Waves, C. M. McClenan, *TM 59*, Nov. 1975.
Wave Climate at Selected Locations Along U.S. Coasts, E. F. Thompson, *TR 77-1*, Jan. 1977.

312-10652-420-00

GREAT LAKES WAVE HINDCASTING TECHNIQUES

(*c*) E. F. Thompson, Hydraulic Engineer, Research Division.
(*d*) Field investigation; applied research.
(*e*) Because wind wave generation in the Great Lakes is complicated by restricted fetches, shallow water, and variable wind field structure due to air-water temperature differences, existing wave hindcasting techniques can be properly evaluated and modified only by comparing their results to wave gage measurements.
To provide data for evaluating existing hindcasting techniques, pressure and buoy wave gages have been operated in the Great Lakes.
(*g*) Wave gage data have been collected in lakes Erie and Michigan during fall 1975-6. The data, in both digital and pen and ink strip chart form, have been analzyed. They are now being used to evaluate significant wave height, period, and energy spectrum produced by some available Great Lakes wave hindcasting techniques.

312-10653-720-00

DEVELOPMENT OF A FIELD RESEARCH FACILITY AT DUCK, NORTH CAROLINA

(*c*) L. L. Watkins, Chief, Research Support Division.
(*d*) Field investigations of coastal phenomena.
(*e*) The Coastal Engineering Research Center (CERC) Field Research Facility (FRF) currently under construction at Duck, North Carolina, will include a 3,300 foot section of the barrier island, a 1,800 foot concrete pier spanning the dunes, beach and surf zone out to a 20 foot (MSL) water depth, a laboratory building, and an instrumented research vehicle to operate on the pier. The facility will provide a permanent field base of operations for carrying out physical and biological studies of an oceanfront site and nearshore area as well as nearby sounds, bays, and barrier islands. The facility will also allow a means of correlating small scale coastal engineering laboratory test results with actual prototype results. Continuous data on coastal phenomena (such as waves, currents, tides, and beach changes) will be monitored across the full width of the surf zone during all weather conditions including severe storms. The ensuing information will result in improved methods for predicting storm damage and in improved designs for restoration and protection of eroded beaches and fragile coastal areas.
(*g*) The concrete pier is nearly complete and is planned for acceptance during June 1977. Instrumentation of the pier will begin during July 1977. Completion of the laboratory building and research vehicle is anticipated during 1978.

312-10654-430-00

OFFSHORE BREAKWATERS FOR SHORE STABILIZATION

(*c*) R. M. Sorensen, Chief, Coastal Structures Branch, Research Division.
(*d*) Experimental, applied research.
(*e*) This study will investigate the use of relatively low crested segmented offshore breakwaters for shore stabilization. The purpose is to determine the influence of crest elevation and width of breakwaters as well as their position and spacing on wave characteristics in the lee in order to evaluate the potential of offshore breakwaters to reduce shore erosion. Two-and three-dimensional wave tank tests will be conducted. The three-dimensional tests will also investigate current patterns, and segmented breakwater location and spacing factors.
(*g*) A literature review has been completed.

312-10655-410-00

NUMERICAL PREDICTION OF SHORELINE EVOLUTION

(*c*) J. R. Weggel, Special Assistant, Engineering Development Division.
(*d*) Theoretical, basic research.
(*e*) The study was initiated in CY 76 to investigate the feasibility of developing a numerical model that would predict the response of a shoreline to changes in wave energy acting on it. Initial conclusions are that an approximate model suitable for use in planning studies can be developed that will provide estimates of the effects of various coastal structures on adjacent shorelines. A detailed literature survey of publications relating to mathematical prediction of shoreline evaluation is proceeding on schedule.
(*g*) Current efforts are being directed toward the development of a numerical computer model based on equations for longshore sediment transport and the mass balance equation for the sediment. The eventual product will be a computer program that will permit preconstruction estimates of the effects of proposed coastal structures, the interaction among several coastal structures along a shoreline and method for estimating the damages attributable to the construction of a given navigation project.

312-10656-430-00

WEIR JETTY STUDY

(*c*) D. W. Berg, Chief, Eval. Br, EDD and J. R. Weggel, Special Asst., Engineering Development Division.
(*d*) Experimental, applied research, development.
(*e*) The three-phase research program will include two series of laboratory experiments and a field measurement program. A series of movable-bed laboratory tests will endeavor to quantify the distribution of sediment transport across a weir jetty for various wave and tidal flow conditions. A second series of tests with a fixed-bed model will establish the hydraulic conditions that can be expected at a weir jetty in different tidal environments and for different geometric configurations. The field measurement program will measure the distribution of sediment transport over a full-scale weir section by mounting sediment traps at various locations along a weir section to determine the transport rate at that section.
(*g*) Expected output from the program will permit designers to use the empirical data in a prescriptive integration procedure to evaluate proposed weir jetty designs and to establish weir crest elevation, orientation and length.

312-10657-410-00

STANDARD COASTAL REVETMENTS

(*c*) R. M. Sorensen, Chief, Coastal Structures Branch, Research Division.
(*d*) Experimental, applied research.
(*e*) The purpose is to provide guidelines to aid in selecting an adequate, affordable revetment scheme for coastal protection along low energy shorelines. Two-dimensional tests are being conducted at prototype scale to evaluate various

protection schemes that use readily available low cost materials which require only one or two people for installation. The study will produce guidelines for design and installation of schemes for protection, eroding shorelines from wave attack.

(*g*) Results of this study will be from a comparison of an unprotected 1 on 5 sand beach with a sand 1 on 15 fronting slope to a similar protected beach for breaking wave heights up to two meters and wave periods of 3.5, 4.6, and 6.0 seconds. Cinder building blocks, sand-cement bags, and Gabions have been selected for use in various protection schemes.

(*h*) **Survey of Coastal Revetment Types,** B. L. McCartney, *MR 76-7*, Coastal Engrg. Research Center, May 1976.
Overlay of Large, Placed Quarrystone and Boulders to Increase Riprap Stability, B. L. McCartney, J. P. Ahrens, *TP 76-19*, Coastal Engrg. Research Center, Dec. 1976.

DEPARTMENT OF THE ARMY, DIVISION HYDRAULIC LABORATORY, NORTH PACIFIC DIVISION, CORPS OF ENGINEERS, Bonneville, Oreg. 97008. Peter M. Smith, Director.

313-04504-350-13

GENERAL MODEL STUDY OF LITTLE GOOSE DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) Little Goose Dam, at Snake River mile 70.3, is the third in a series of multiple-purpose dams being constructed above the mouth of Snake River for power, navigation, and other uses. Salient features include an 8-bay spillway, a navigation lock 86 feet wide by 675 feet long (maximum lift 101 feet), a powerhouse for six units (initial installation three 135,000-kW generators), and a 20-foot wide fish ladder on the south shore. A model study was necessary to determine minimum excavation requirements, to verify structure locations, and to check the overall effects of these structures on navigation, power generation, and fish passage. A general model, constructed to a linear scale ratio of 1:100, reproduced the river channel and pertinent overbank areas for 1.35 miles upstream and .1.90 miles downstream from the project axis.
(*f*) Completed.
(*h*) **Little Goose Dam, Snake River, Washington,** R. L. Johnson, L. Z. Perkins, *Div. Hydr. Lab. Tech. Rept. No. 110-1*, Apr. 1975.

313-05068-350-13

MODEL STUDY OF SPILLWAY FOR LITTLE GOOSE DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 313-04504 for description of project. A 3-bay section of the 8-bay spillway and stilling basin was reproduced in a 1:42.45-scale model. The purposes of the tests were to check performance of the original spillway and to develop revisions that would improve performance or reduce construction and maintenance costs.
(*f*) Completed.
(*h*) **Spillway for Little Goose Dam, Snake River, Washington,** R. L. Johnson, L. Z. Perkins, *Div. Hydr. Lab. Tech. Rept. No. 114-1*, Apr. 1975.

313-05069-350-13

MODEL STUDY OF NAVIGATION LOCK FOR LITTLE GOOSE DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 313-04504 for description of project. The intake manifolds, longitudinal culverts (both in right wall), lock chamber, split lateral filling and emptying system, outlet culverts, and portions of the approach and outlet areas were reproduced in a 1:25-scale model. An alternative method for distributing flow to the lateral culverts from a central junction chamber was studied in an auxiliary 1:25-scale model of the lock chamber. The purposes of the studies were to check the suitability of the original design and to develop improvements if necessary.
(*f*) Completed.
(*h*) **Filling and Emptying System, Little Goose Lock, Snake River, Washington,** L. Z. Perkins, A. J. Chanda, *Div. Hydr. Lab. Tech. Rept. No. 115-1*, Sept. 1975.

313-05070-350-13

MODEL STUDY OF SPILLWAY FOR DWORSHAK DAM, NORTH FORK CLEARWATER RIVER, IDAHO

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) Dworshak Dam, on the North Fork of Clearwater River will furnish 400,000 kW of power from three units (initial installation) and, ultimately, 1,060,000 kW from six units. The spillway consists of two 50-foot wide bays, with crest at elevation 1545, a chute, and a 114-foot wide, 271-foot long stilling basin at elevation 931. Three 9- by 12.5-foot regulating outlets, upstream from the tainter valves, and 11 by 17 feet downstream from valves, discharge on the spillway chute. Total capacity of the spillway and regulating outlets is 221,000 cfs at pool elevation 1604.9. Approximately 1.6 miles of river channel and pertinent overbank topography were reproduced in a 1:50-scale model to study the cofferdam and diversion tunnel. A section of forebay, the spillway, regulating outlets, stilling basin, powerhouse, tailrace, and exit channel were reproduced to determine hydraulic characteristics of these elements.
(*f*) Tests completed; final report in preparation.
(*g*) See 1970 issue.

313-05071-350-13

GENERAL MODEL STUDY OF LOWER GRANITE DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) Lower Granite Dam, at Snake River mile 107.5, is 37.2 miles upstream from Little Goose Dam. The 8-bay spillway, with 50- by 60.5-foot control gates (tainter) and the 498-foot wide, 167-foot long nonbaffled stilling basin are designed for a maximum discharge of 850,000 cfs. The 6-unit powerhouse will have a capacity of 810,000 kW; initial installation 405,000 kW from three units. The 86- by 675-foot navigation lock will have a maximum single lift of 105 feet. Fish facilities include a powerhouse collection system, three pumps for additional attraction flow (2550 cfs) and one 20-foot wide fish ladder with floor slope of 1 on 10. A 1:100-scale general model reproduced the riverbed and pertinent overbank topography between Snake River miles 106.1 and 108.9 and successive phases of construction. Construction stages, powerhouse tailrace limits and depths, navigation lock approaches, flow conditions affecting fish passage, and project operations were to be studied in the model.
(*f*) Tests completed; final report in preparation.
(*g*) The first-step cofferdam and diversion channel were satisfactory after the channel entrance was modified and rock groins to aid fish migrations were added. Embankment and excavation limits for construction phases were determined. The effects of several stages of erosion downstream from the original stilling basin were investigated, and an improved basin design was developed with estimated maximum erosion in the tailrace. Satisfactory energy dissipation was obtained with the stilling basin raised 4 ft and a 9-ft end sill (originally 11 ft high). An undesirable eddy existed between the north fishway entrance and the navigation lock wall. Several combinations of walls, fills, and training wall extensions were tried in efforts to develop satisfactory conditions at the north fishway entrance. Development of modifications to reduce nitrogen supersaturation caused by spillway discharges was

begun. Preliminary results indicate that 12.5-ft wide horizontal deflectors on the spillway ogee will produce stable "skimming flow" in the stilling basin for river flows up to thc 10-year flood, and required energy dissipation will occur at high flows; see also 317-07120.

313-05315-350-00

MODEL STUDY OF REGULATING OUTLETS FOR DWORSHAK DAM, NORTH FORK CLEARWATER RIVER, IDAHO

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 313-05070 for description of project. The three regulating outlets, with intakes at elevation 1350, will operate under heads of from 95 feet at minimum pool elevation 1445 to 254.9 feet at maximum pool elevation 1604.9. Total outlet capacity will be 40,000 cfs at pool elevation 1604.9. Pressures, flow conditions, and discharge relationships were observed in a 1:25-scale sectional model that reproduced a portion of the forebay, the right conduit, and a section of the spillway chute. The purpose of the study was to check the adequacy of the original design and to develop revisions if necessary.
(*f*) Tests completed; final report in preparation.
(*g*) Four designs for a bellmouthed intake were studied. See 1970 issue for details.

313-05316-850-13

MODEL STUDY OF FISH LADDER FOR LITTLE GOOSE DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 313-04504 for description of project. A 1:10-scale model was used for tests of a 20-foot wide fish ladder with floor slope of 1 on 10.
(*f*) Completed.
(*h*) **Fish Ladders for Little Goose and Lower Granite Dams, Snake River, Washington,** *Div. Hydr. Lab. Tech. Rept. No. 129-1*, Oct. 1976.

313-05317-330-13

MODEL STUDY OF COLUMBIA RIVER, OAK POINT TO VANCOUVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Portland.
(*d*) Experimental; for design.
(*e*) The project will increase the navigation channel width from 500 feet to 600 feet and the depth from 35 to 40 feet between Columbia River miles 52 to 109 and from the mouth of Willamette River to Portland, Oregon. Project depths and widths will be maintained by a system of pile dikes and by dredging. Five separate movable-bed models with 1:300 horizontal and 1:100 vertical scales will be required to cover improvements in the Columbia River. The models will be used initially to check plans for constructing and maintaining the 40-foot channel. Later the models will be used to check operation and maintenance activities and new construction. The first two models include river miles 53 to 65 and 64 to 78, respectively. Work on the remaining three models has not begun.
(*f*) Scheduled tests of river miles 53 to 78 completed; final report in preparation.
(*g*) Shoaling indexes, based on results with an uncontrolled 40-foot deep navigation channel, were determined for each improvement plan tested in the models. Satisfactory plans are being developed for all problem reaches covered by both models. Alternative proposals, which would be more acceptable to local interests in the Longview-Rainier area (mile 66), were tested and the benefits of these plans were determined.

313-07107-350-13

MODEL STUDY OF SECOND POWERHOUSE FOR BONNEVILLE DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U.S. Army Engr. Dist., Portland.
(*d*) Experimental; for design.
(*e*) The existing project includes an 18-bay spillway with vertical gates lifted by 350-ton gantry cranes, a powerhouse with total rated capacity of 518,000 kW from 10 main units and one station service unit, a navigation lock with net clear dimensions of 76 by 500 feet, and fish facilities on each side of the river. Head on the project varies between 30 and 70 feet. From four to ten additional units are proposed to utilize increased storage and peaking operations at upriver projects. A 1:100-scale fixed-bed model reproduces the existing structures, riverbed, and pertinent overbank topography between river miles 142.2 and 146.8. A remote controlled towboat and tow are used to evaluate the effect of additional power units on navigation. The purpose of the study is to confirm the site chosen for the second powerhouse and to study flow conditions affecting fish passage, navigation, and head on the project.
(*g*) Three structures and excavation plans were investigated. Tests of the recommended plan (with present lock and provision for a future lock on the Oregon shore and an eight-unit powerhouse on the Washington shore) were continued. Tests indicated that 12-ft-long horizontal deflectors at elev. 14 between piers on the spillway ogee will produce stable "skimming flow" in the stilling basin for normal tailwater levels with the present 10-unit powerhouse and spillway flows between 1,000 and 16,000 cfs per bay. This should reduce levels of dissolved nitrogen downstream from the spillway. Spillway operating schedules were developed to provide good conditions for upstream passage of fish. This information was used in 1974 to evaluate the effects on fish passage of prototype deflectors in bays 13, 14, and 15 of the 18-bay spillway; see also 313-07108. Placement of construction spoil on the floodplain downstream caused an acceptable rise in tailwater of 3 ft at the dam with the maximum probable flood.

313-07108-350-13

MODEL STUDY OF SPILLWAY GATE MODIFICATION FOR BONNEVILLE DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U.S. Army Engr. Dist., Portland.
(*d*) Experimental; for design.
(*e*) See 313-07107 for description of project. Additional pondage at Bonneville Dam will be required to accomodate water released by future increased power peaking of upstream dams. All spillway gates will be made 60 ft high (some are 50 ft high) to provide the necessary pondage, and 10 of the gates will have individual hoists to allow remote control. The present gates cannot be operated under certain conditions because of vibration and a tendency to bounce. Remote control of spillway gates requires no known restrictions on spillway operation. A 1:25-scale model included one spillway bay, two half piers, one spillway gate, and a 60-ft wide section of stilling basin and adjacent approaches. The gate was free to move vertically in the gate slots. The study was extended to include the hydraulic characteristics of deflectors between the piers on the spillway ogee. These devices may reduce nitrogen supersaturation by causing air entrained by small to moderate spillway discharges to remain near the water surface. Purposes of the studies are to check performance of existing gate bottoms and proposed deflectors and to develop improved designs if required.
(*f*) Completed.
(*h*) **Spillway Gate Modification, Bonneville Dam, Columbia River, Oregon and Washington,** T. D. Edmister, P. M. Smith, *Div. Hydr. Lab. Tech. Rept. No. 136-1*, May 1975.

313-07109-350-13

MODEL STUDY OF INCREASED POOL ELEVATIONS AT SPILLWAY OF CHIEF JOSEPH DAM, COLUMBIA RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Seattle.
(*d*) Experimental; for design.

(*e*) The existing project, located 51 miles below Grand Coulee Dam and 545 miles from the mouth of Columbia River, includes an excavated channel leading to an intake for 27 penstocks, a 20-unit powerhouse (initial installation 16 Francis turbines), and a spillway with nineteen 40-ft-wide bays surmounted by 9-ft-wide piers and 56.2-ft-high tainter gates. The spillway ogee was designed for a head of 41.6 ft on the crest, or 75 percent of the computed maximum total head of 55.4 ft at the project design flow of 1,250,000 cfs. Construction of a third powerhouse at Grand Coulee Dam will require additional storage and power units at Chief Joseph to use the increased flow. Present plans include raising the Chief Joseph pool from existing elevations 946 to maximum elevations 970, or up to 1.7 times the design head: Preliminary data on surge characteristics at the spillway were obtained in an existing spillway model that contained a standard high dam crest and piers with elliptical noses. The most suitable modifications (13-foot thick piers, 36-foot wide bays, gate radius 55 feet, gate trunnions at elevation 920 and 61.83 feet from existing crest axis) were studied in a 1:43.35-scale model. Water-surface elevations at the outlet of a 4-foot diameter relief tunnel in the right training wall were determined for uniform and varied operations of spillway gates during spillway flows of 50,000 to 550,000 cfs (powerhouse discharge 250,000 cfs).

(*f*) Tests completed; final report in preparation.

(*g*) The tests indicated that the original crest and stilling basin would be satisfactory. Surging of flow on higher, narrower spillway gates was severe at large partial gate openings. This unstable periodic surge resulted from the combined effects of structural geometry, large heads, and gate openings required to release desired flows. Surging in the narrow bays was reduced from a maximum of 10.8 feet (pool elevation 961.2 and gates open 35 feet) to 2.8 feet by suppressors that extended 4 feet from the side of each pier above the maximum nappe at free flow. Closing the right spillway gate allowed the relief tunnel to drain until the river discharge exceeded 800,000 cfs. A vertical deflector projecting 2 feet from the training wall just upstream from the relief tunnel outlet would reduce water levels in the tunnel and allow uniform spillway operation for most discharges.

313-07110-350-13

MODEL STUDY OF CONDUIT ENTRANCES FOR DWORSHAK DAM, IDAHO, AND LIBBY DAM, MONTANA

(*b*) U.S. Army Engr. Dist., Walla Walla and Seattle.

(*d*) Experimental; for design.

(*e*) Normal reservoir outflows at Dworshak and Libby Dams will discharge on the respective spillway chutes through conduits that operate under heads up to 250 feet on the regulating valves (tainter). Although conduit dimensions upstream from the valves differ (9 by 12.5 feet at Dworshak and 10 by 17 feet at Libby), the same type of bellmouthed intake will be used at both dams. The tentatively adopted "no-skew" intakes that were developed during the Dworshak conduit model study extended upstream beyond the face of the dam. This would have complicated design and use of unwatering bulkheads. A regulating conduit with streamlined entrance and a portion of forebay were reproduced in a 1:20-scale model for measurements of discharges, pressures, and other data. The purpose of the study was to develop revisions that could be used at Dworshak, Libby, or other projects.

(*f*) Tests completed; final report in preparation.

(*g*) Three designs for short, skewed, bellmouthed entrances for the Dworshak and Libby conduits were tested. Satisfactory plans for both entrances were developed.

(*h*) **Skewed Entrance for High-Head Conduits,** *Engineer Technical Letter No. 111-2-41*, Dept. of the Army, Office of the Chief of Engrs., Washington, D. C., May 1968.

313-07111-850-13

MODEL STUDY OF FISHWAY DIFFUSER FOR DWORSHAK DAM, NORTH FORK CLEARWATER RIVER, IDAHO

(*b*) U.S. Army Engr. Dist., Walla Walla.

(*d*) Experimental; for design.

(*e*) See 313-05070 for description of project. Adult fish will be attracted into a collection channel leading to a holding pool from which they will be transported to a hatchery, to the reservoir, or to another stream. Water for operation of the fish facilities will be pumped from tailwater, and distributed by means of six diffusion chambers into the collection system holding pool, and hopper pool. A typical diffusion chamber and portions of the adjoining supply conduit and collection channel were reproduced in a 1:10-scale model. Flow in the conduit varied from 100 to 480 cfs, diffuser discharge was 60 cfs, and a differential head of 2.5 feet existed between the supply conduit and collection channel. The purposes of the study were to check the adequacy of a typical diffusion chamber and to develop revisions if required.

(*f*) Tests completed; final report in preparation.

(*g*) See 1970 issue.

313-07112-850-13

MODEL STUDY OF HATCHERY JET HEADER FOR DWORSHAK DAM, NORTH FORK CLEARWATER RIVER, IDAHO

(*b*) U.S. Army Engr. Dist., Walla Walla.

(*d*) Experimental; for design.

(*e*) See 313-05070 for description of project. A new type of rearing pond, developed by the U.S. Fish and Wildlife Service, will be adapted for use at the Dworshak fish hatchery. Circulation in each pond will be provided by two jet headers that discharge between 70 and 400 gpm (0.17 to 0.89 cfs). One header, constructed full-scale of aluminum pipe, was attached to an existing water supply, tank, and weir box. The purpose of the study was to determine head-discharge relations and jet velocities for 1-1/4 and 1-inch nozzles.

(*f*) Tests completed; final report in preparation.

(*g*) See 1970 issue.

313-07114-850-13

MODEL STUDY OF REVISIONS FOR FISH LADDERS AT JOHN DAY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.

(*d*) Experimental; for design.

(*e*) John Day Dam is on the Columbia River 25 miles upstream from The Dalles, Oregon. The 5900-foot-long dam provides 76 miles of slack water for navigation to McNary Dam and 500,000 acre-feet of flood storage. The dam has a 20-bay spillway (2,250,000 cfs), 20-unit powerhouse (16-135,000 KW units installed), 113-foot single lift navigation lock, and two fish ladders. Based on tests in a previous model (3578 in 1970 issue of HRUSC) an 18-pool submerged orifice regulating section was developed for the north fish ladder. The design incorporated a horizontal counting station between the fixed weir and regulating sections. A similar type of regulating section was used in the south fish ladder; a vertical-board-type counting station was located in the sloping portion of the ladder. Difficulties with passage of fish (especially shad) led to studies of vertical-slot regulating sections for both the north and south ladders. A 1:10-scale model was used for tests of 23 pools of the north fish ladder and then the exit, regulating section, auxiliary water diffusion chamber, fish counting station, and eight pools downstream from the counting station. The model was used to check proposed revisions and to develop modifications to them. Similar tests were made for the south ladder where the design differed from the north ladder.

(*f*) Tests completed; final report in preparation.

(*g*) A new, very effective design of vertical-slot regulating section incorporating twice the usual number of pools with a maximum water surface drop of 6 in. per pool was developed. After full-scale test of six pools with fish in the National Marine Fisheries Service Laboratory, North Bonneville, Wash., the south ladder at John Day was modified to this design. After a full season of very successful fish passage, the north ladder also was revised.

313-07117-350-13

MODEL STUDY OF SPILLWAY FOR LIBBY DAM, KOOTENAI RIVER, MONTANA

(*b*) U.S. Army Engr. Dist., Seattle.
(*d*) Experimental; for design.
(*e*) Libby Dam, at Kootenai River mile 219, 17 miles upstream from Libby, Montana, will include a spillway with two 48-ft wide bays with crests at elevation 2405, three 10- by 17-ft regulating outlets, and a powerhouse for eight Francis units (ultimate installation 840,000 kW). Three powerhouse units (total capacity 315,000 kW) will be installed initially. At maximum pool elevation 2459, spillway capacity will be 145,000 cfs and total capacity of regulating outlets will be 61,000 cfs. The 116- by 300-ft stilling basin, at elevation 2073, is designed for a maximum spillway discharge of 50,000 cfs. A 1:50-scale model reproduced a portion of the forebay, all hydraulic elements of the spillway and powerhouse, and 1600 ft of exit channel. The initial purpose of the model was to check the adequacy of the spillway, regulating outlets, stilling basin, and excavated outlet channels. The scope of the study was increased to include tests of diversion plans and flow conditions with a powerhouse selective withdrawal structure.
(*f*) Tests completed; final report in preparation.
(*g*) The model tests showed that the original spillway abutments, center pier, chute, and stilling basin were not satisfactory. During development tests, the bulkhead slots and upstream projections of pier and abutments were eliminated and the circular abutments were changed to elliptical. The center pier was narrowed from 24 to 20 ft, and both sides of the pier were tapered. A tapered extension of the center pier was used to reduce undesirable rooster tail in flow down the chute. The original stilling basin was 120 ft wide and 172.8 ft long at elevation 2074, and the basin walls were at elevation 2127. The adopted basin is 116 ft wide, 300 ft long, at elevation 2073, and the sidewalls are at elevation 2142. Sizes of rock needed for riprap in exit areas were determined. Six diversion plans were studied before an acceptable plan was selected. Several types of deflectors to prevent debris from lodging against the legs of a contractor's tower were investigated for flows greater than 50,000 cfs during second-stage construction. The adopted plan consisted of two concrete piers 15 ft high and 87 ft long. Each pier acted as a deflector and later would become part of the mass concrete monolith. Tests of the selective withdrawal structures indicated that overflow bulkheads on the face of the intake must be submerged about 20 feet to supply the turbine unit flow of 5800 cfs at pool elevation 2459. The pier nose shapes were revised and a floating skimmer device was developed to prevent vortex action and air entrainment at intakes of the selective withdrawal structure. Scheduled studies with flow into a single powerhouse unit from a density-stratified reservoir have been completed.
(*h*) **Selective Withdrawal System, Libby Dam, Kootenai River, Montana,** A. G. Nissila, P. M. Smith, *Div. Hydr. Lab. Tech. Rept. No. 125-2*, Dec. 1975.

313-07118-350-13

MODEL STUDY OF OUTLET WORKS FOR LOST CREEK DAM, ROUGE RIVER, OREGON

(*b*) U.S. Army Engr. Dist., Portland.
(*d*) Experimental; for design.
(*e*) Lost Creek Dam on the Rouge River will provide 315,000 acre-feet of usable storage for flood control and other uses and 49,000 kW of electric power. A multiple-use intake tower with openings at four levels will lead to a 15-foot diameter penstock and to a 12.5-foot diameter regulating outlet. A 6- by 12-foot bypass will permit reservoir releases through the penstock when the intake tower is unwatered. The spillway will include three 45-foot bays. Design discharges are as follows: outlets works 9860 cfs at minimum pool elevation 1812, and 11,460 at maximum pool elevation 1872; bypass 2000 cfs; spillway 158,000 cfs. A 1:40-scale model reproduced a portion of forebay, the multiport intake tower, regulating outlet intake valve section, conduit and chute, stilling basin, penstock intake and curve, powerhouse, and a section of downstream channel. Flow conditions and pressures in the tower bypass system were studied in a separate 1:40 scale model. The purposes of the study were to investigate flow conditions and pressures in the intake tower, regulating outlet, and penstock; to measure discharges through the regulating valves and bypass intake; and to check performance of energy dissipator, tailrace, and downstream channel.
(*f*) Tests completed; final report in preparation.
(*g*) Flow conditions and pressures at the intakes of both models were satisfactory. An 80 ft long section of chute walls of original design was overtopped as much as 3 ft during the chute design discharge of 12,000 cfs. The stilling basin was adequate from a hydraulic standpoint. However, the air entrainment and resulting nitrogen supersaturation downstream from this type of basin were not acceptable. Tests indicated that an alternative design with revised chute and a 30-degree, 50-ft radius flip bucket would be satisfactory. Wave suppressors 4 ft wide by 8 ft long were required on the chute walls to prevent overtopping.

313-07119-850-13

MODEL STUDY OF FISH LADDER FOR LOWER GRANITE DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 313-05071 for description of project. The 1:10-scale model included weirs at the upper end of the 20-foot wide, 1-on-10 slope ladder, followed in turn by a 17-foot long diffuser pool, the 1-on-32 slope regulating section with 10 orifice and slot bulkheads on 16-foot centers, the 6-foot wide exit channel, and a section of forebay. The purposes of the investigation were to determine the adequacy of the proposed orifice-slot control section and to develop improvements if required.
(*f*) Completed.
(*h*) **Fish Ladders for Little Goose and Lower Granite Dams, Snake River, Washington,** *Div. Hydr. Lab. Tech. Rept. No. 129-1*, Oct. 1976.

313-07120-350-13

MODEL STUDY OF SPILLWAY FOR LOWER GRANITE DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 313-05071 for description of project. The 1:42.47-scale model included a 3-bay section of the 8-bay spillway, stilling basin, and approach channels. The study was expanded to include the hydraulic characteristics of horizontal deflectors with and without dentates on the spillway ogee. These devices may reduce nitrogen supersaturation by causing air entrained by small to moderate spillway discharges to remain near the water surface in the stilling basin. The purposes of the model are to check designs for the spillway crest, piers and abutments, chute, stilling basin, excavated channel, deflectors on the spillway ogee, and to develop revisions if required.
(*f*) Tests completed; final report in preparation.
(*g*) No revisions of the original crest and piers were required. Discharge rating curves for both free and gated flows were obtained. Satisfactory agreement was not obtained between tailwater-jump curves measured in the spillway model and in the general model (study 5071). Return flow into the stilling basin from the powerhouse tailrace and expansion of flow along the lower lock guard wall were responsible for the differences. The final design for the stilling basin will be based on tests in the general model.

Tests in the spillway and general models indicate that a 12.5-foot wide horizontal deflector at elevation 630 (crest elevation 681) will produce desired stable, shallowly aerated, "skimming flow" in the stilling basin for spillway discharge 10,000 cfs per bay. Skimming action was improved by adding three rows of 1.8- by 2.6-ft dentates to ogee and deflector. Pressures on the deflector were positive.. Cavitation may develop on the dentates. Use of deflectors and dentates does not reduce the energy dissipating capability of the stilling basin at high flows.

317-07121-330-13

MODEL STUDY OF NAVIGATION LOCK FOR LOWER GRANITE DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental for design.
(*e*) See 313-05071 for description of project. In the unusual hydraulic system, a central junction chamber connects both longitudinal culverts to eight symmetrically-located longitudinal port manifolds (four upstream and four downstream) in the floor of the lock. There are six pairs of ports in each manifold. A 1:25-scale model reproduced a portion of the forebay and floating guide wall, the hydraulic system, the lock chamber, and portions of exit areas and downstream approach. The purposes of the investigation were to check the adequacy of the proposed design and to develop modifications if required.
(*f*) Tests completed; final report in preparation.
(*g*) See 1970 issue.

313-07123-330-13

MODEL STUDY OF NAVIGATION LOCK FOR LOWER MONUMENTAL DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) Except for the intake manifolds, which are staggered in the upstream channel, essential features of the hydraulic system are similar to those previously model-tested and adopted for use at John Day Dam. The 1:25-scale John Day lock model was revised for this study by using the longitudinal culvert intake (John Day elevation 114 = Lower Monumental elevation 396) for elevation control, installing new upstream culvert transition and intake manifolds, and lowering the approach floor 4 feet for correct depth at intakes. The main purpose of the model study was to obtain acceptable flow conditions (no vortex formation) over the intake manifolds. Pressures in the culvert and hydraulic loads on a proposed revision of the lock emptying valves (skin plate upstream) were measured in the Lower Granite lock model.
(*f*) Completed.
(*h*) **Intake Manifolds and Emptying Valves for Lower Monumental Lock, Snake River, Washington,** L. Z. Perkins, H. P. Theus, *Div. Hydr. Lab. Tech. Rept. No. 105-1*, May 1975.

313-08442-850-13

FISH HATCHERY AERATOR AND DEAERATOR TESTS

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) Filtered water, aerated, deaerated, and temperature regulated, will be recirculated through systems of headers and nozzles into rearing and holding ponds of several fish hatcheries that are being installed by the Corps of Engineers. Each pair of nozzles is designed to discharge 250 gpm (125 gpm per nozzle). One bank of 28 pairs of aerator nozzles (total discharge 7000 gpm) will be supplied by a 16-inch header pipe. Another bank of 16 nozzles (4000 gpm) will be supplied by a 12-inch header. Two banks of deaerators will be supplied by 6- and 8-inch headers (respective discharges 750 and 1000 gpm). Equal pressures are desired in both sets of headers. The purpose of the investigation was to calibrate aerator and deaerator systems of commercial black iron and PVC plastic pipe.
(*f*) Tests completed; final report in preparation.
(*g*) Pressures, discharges, and air demands were measured for four sizes of aerator pipe. Pressures and discharges were determined for four sizes of deaerator pipe.

313-08443-350-13

MODEL TESTS OF RELIEF PANEL FOR SELECTIVE WITHDRAWAL GATES AT DWORSHAK DAM, NORTH FORK CLEARWATER RIVER, IDAHO

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 313-05070 for description of project. Selector gates of the multi-level power intakes will have 90 pressure relief panels per power intake to protect the gates against failure from internal waterhammer or excessive differential pressures caused by misoperation of the gates or power units. The panels will consist of butterfly valves mounted on torsion bars. A 1:5-scale model was used to determine torque on the shaft of a 1- by 4-foot panel and discharge for various openings under differential heads of 3 to 20 feet. The data were needed to verify and supplement design computation.
(*f*) Tests completed.
(*g*) Torque and discharge were measured for panel openings of 10, 20, 30, 40, and 45 degrees and heads of approximately 3 to 20 feet. Torque decreased with panel opening until a negative value was reached at an opening of 47 degrees. The maximum torque, 1869 foot-pounds, was measured at a differential head of 18.37 feet and a panel opening of 10 degrees.

313-08444-350-13

MODEL STUDY OF POWERHOUSE SKELETON UNIT FOR LOWER GRANITE DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 313-05071 for description of project. A 1:40-scale model reproduced a proposed powerhouse skeleton unit and sections of approach and exit channel. The study was to determine the maximum discharge as limited structurally that could be released through a unit without entraining air and causing or increasing nitrogen supersaturation of flow passing the project, and the best method of controlling the discharge.
(*f*) Tests completed; final report in preparation.
(*g*) Initially, the operating gates were tested as flow controls. Then the gates in combination with stoplogs in the gate and intake slots were investigated. From these studies, a bulkhead with slots or converging tubes was developed for prototype tests in a similar unit at Little Goose Dam during the spring freshet in 1971. Slots in the top seven rows were 4 inches high; the lower eight slots were 6 inches high (area 95 sq. ft.). The slot tubes converged on slopes of 1 on 4.27 and 1 on 4.78, respectively. The skeleton unit discharged 21,200 cfs (discharge coefficient 0.932) under 99 feet of head between forebay and tailwater. Positive pressures were measured within the converging tubes and on the piers at the operating gate slots. Flow conditions within the skeleton bay were turbulent but satisfactory. Full-height, 12-inch deflectors attached to the left faces of intake piers reduced upwelling in the left downstream corner of the bay. Measurements at Little Goose Dam showed no increase in nitrogen supersaturation in flow downstream from a bulkhead skeleton unit. Discharges were measured and flow conditions were determined with and without slotted bulkheads upstream from partially-completed units with scroll case and wicket gates installed.

313-08445-350-13

MODEL STUDY OF POWERHOUSE SKELETON UNIT FOR ICE HARBOR DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) Ice Harbor Dam is located on the Snake River 9.7 miles upstream from the Columbia River. Principal features include a six-unit powerhouse, an eight-bay spillway, a 103-

foot single lift navigation lock, and two fish ladders. The study was made to develp a satisfactory design for slotted bulkheads which would allow passage of the maximum flow through a skeleton unit without entraining air. Entrained air would cause or increase nitrogen supersaturation of flow passing the project. A 1:40-scale model reproduced an existing powerhouse skeleton unit and sections of approach and exit channel.

(*f*) Tests completed; final report in preparation.

(*g*) The original bulkhead design, which was based on the design developed in the Lower Granite skeleton unit model (313-08444), was not satisfactory when tested in the Ice Harbor model because of submergence differences. An alternative plan with three 8-inch, four 6-inch, and five 4-inch slots (bottom to top, area 84.5 sq. ft.), provided satisfactory control of turbulence and aeration and a discharge of 19,200 cfs per unit. Nearly unrestricted movement of operating gates when activating or deactivating the skeleton unit was possible.

313-08446-350-13

MODEL STUDY OF ORIFICE BULKHEADS FOR POWERHOUSE SKELETON UNITS AT JOHN DAY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.

(*d*) Experimental; for design.

(*e*) The purpose of the study was to develop a design for orifices in bulkheads to control discharges through skeleton powerhouse units without air entrainment that would increase nitrogen supersaturation below the dam. These skeleton units differ from those tested for other projects in that more concrete was added to the turbine bays. A final stage skeleton unit and sections of approach and discharge channels were tested in a 1:40-scale model.

(*f*) Completed; final report in preparation.

(*g*) Modifications tested included a temporary roof over the turbine bay, a partition on the intake roofs, and slotted bulkheads in the intake bays. Tests were made on four plans with a bulkhead in all three intakes and on seven plans with a bulkhead in the center intake only (no flow through the other intakes). Although conditions with the temporary roof and three bulkheads were acceptable, these modifications would be very costly. With a single bulkhead, heads on interior walls, pressures on the bulkhead, and air entrainment were excessive.

313-08447-350-13

MODEL STUDY OF SPILLWAY FOR LOWER MONUMENTAL DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.

(*d*) Experimental; for design.

(*e*) Develop spillway flow deflectors that will produce stable "skimming flow" in the stilling basin, reduce deep air penetration and nitrogen supersaturation, and still allow good energy dissipation at high discharges. A three-bay section of upstream approach, spillway, stilling basin, and downstream channel were reproduced in a 1:42.47-scale model.

(*f*) Completed; final report in preparation.

(*g*) Air pentration, flow directions and flow stability in the stilling basin were observed with and without deflectors on the spillway chute. Without deflectors, flows of 5,175 to 15,000 cfs per bay carried large amounts of entrained air to the invert of the stilling basin. Three lengths of deflectors (15, 12.5, and 10 ft) were tested for discharges of 2,560 to 106,250 cfs per bay. The best design, a 12.5-ft deflector at elevation 434, provided stable skimming flow for river discharges to 251,000 cfs (15,000 cfs per bay with flow through six powerhouse units). These deflectors did not reduce stilling basin capacity at higher flows. Three rows of 1.8-ft-wide by 2.6-ft-high dentates located on and just upstream from the deflectors further reduced air penetration and stabilized flow in the stilling basin. Tests in one prototype bay in 1972 indicated that the deflector did reduce nitrogen supersaturation, but areas of concrete just downstream from the dentates were severely damaged by cavitation and debris. Additional tests, without dentates, were made in a general spillway model (see separate report).

313-09341-350-13

MODEL STUDY OF SPILLWAY DEFLECTORS FOR ICE HARBOR DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.

(*d*) Experimental; for design.

(*e*) See 313-08445 for description of project. The purpose of the study was to develop deflectors on the spillway ogee to reduce deep air entrainment in the stilling basin and nitrogen supersaturation downstream from the spillway. A three-bay section of upstream approach, spillway, and exit channel were reproduced in a 1:40-scale model.

(*f*) Tests completed; final report in preparation.

(*g*) Spillway discharges of 17,500 cfs or less per bay (river discharge 250,000 cfs or less) were of primary concern because these flows occur during the most important runs of fish. The best overall reduction in depth and quantity of air penetration was obtained with 12.5-ft-wide by 50-ft-long deflectors at elevation 336. With these deflectors, surging occurred in the stilling basin for spillway flows of 13,000 to 25,000 cfs per bay. Additional tests will be made in a 1:50-scale general spillway model.

313-09342-350-00

MODEL STUDY TO REDUCE NITROGEN SUPERSATURATION, LIBBY REREGULATING DAM, KOOTENAI RIVER, MONTANA

(*b*) U.S. Army Engr. Dist., Seattle.

(*d*) Experimental; for design.

(*e*) See 313-09345 for location of project. The study was made to develop a spillway structure that would reduce dissolved nitrogen in supersaturated water flowing over it to approximately 100 percent saturation.

(*f*) Completed; final report in preparation.

(*g*) In a full-scale test facility dissolved nitrogen was removed from supersaturated water as it was highly aerated and agitated while passing down a baffled chute. Three shapes and two sizes of baffles and two chute slopes were tested. A special baffle shape was developed. In a 25.11-scale model a spillway with tainter gates, a stilling area, and a chute with the special baffles was developed. The spillway would pass 8,500 cfs per 50-foot bay with the hydraulics developed in the test facility and pass a probable maximum flood flow of 42,000 cfs per bay satisfactorily. Pressures on the baffles were measured to determine hydraulic loading.

313-09343-350-13

MODEL STUDY OF PRESSURE RELIEF PANELS FOR SELECTOR GATES, LIBBY DAM, KOOTENAI RIVER, MONTANA

(*b*) U.S. Army Engr. Dist., Seattle.

(*d*) Experimental; for design.

(*e*) See 313-07117 for description of project. Each power unit is protected by 36 relief panels in bulkheads of the selective withdrawal structure. The purpose of the study was to assure that the proposed pressure relief panels will protect the selective withdrawal structure from excessive upstream or downstream heads caused by powerhouse load rejections or misoperations. A 1:5-scale model reproduced a 3- by 6-ft relief panel, hinged at the top, and the panel frame.

(*f*) Completed.

(*h*) **Selective Withdrawal System, Libby Dam, Kootenai River, Montana,** A. G. Nissila, P. M. Smith, *Div. Hydr. Lab. Tech. Rept. No. 125-2*, Dec. 1975.

313-09344-350-13

MODEL STUDY TO REDUCE NITROGEN SUPERSATURATION, LIBBY DAM, KOOTENAI RIVER, MONTANA

(*b*) U.S. Army Engr. Dist., Seattle.

(*d*) Experimental; for design.

(*e*) See 313-07117 for description of project. The purpose of the study was to develop flow deflectors or other devices on the sluices and spillway that will allow discharge through the stilling basin with a minimum of air entrainment and nitrogen supersaturation downstream from the project. The spillway, regulating outlets, stilling basin, and portions of the forebay and tailrace were reproduced in a 1:50-scale model.
(*f*) Completed; final report in preparation.
(*g*) Flip buckets and deflectors below the sluice outlets and slotted bulkheads in the sluice intakes were investigated singly and in combination. Flow conditions with three short 10-degree deflectors were good for a sluice flow of 10,000 cfs and unsatisfactory at discharges higher than 20,000 cfs. None of the plans was adequate for the initial period of no power flow. The tests were discontinued.

313-09345-350-00

MODEL STUDY OF LIBBY REREGULATING DAM, KOOTENAI RIVER, MONTANA

(*b*) U.S. Army Engr. Dist., Seattle.
(*d*) Experimental; for design.
(*e*) Flow conditions at the dam during construction and after completion are to be studied in a 1:80-scale model. The model reproduces the Kootenai River channel and pertient overbank topography for one upstream and two miles downstream for the dam site. All pertinent interim and permanent structures will be reproduced. The project design and probable maximum flood discharges for the project are 42,000 and 210,000 cfs. The dam will be near Libby, Montana, 11 miles below the existing Libby Dam.
(*f*) Active; being verified.

313-09346-350-13

MODEL STUDY OF FALSE WEIR AND FISH LADDER, CHARLES RIVER, MASSACHUSETTS

(*b*) U.S. Army Engr. Division, New England.
(*e*) To check the adequacy of proposed designs for the false weir and slot-type fishway and to develop improved designs if necessary. A 1:4-scale model reproduced the false weir, inflow pipe and part of the first pool downstream from the false weir. A 1:8-scale model included the false weir, 29-pool fish ladder, diffusion chambers for attraction flow, and a section of downstream approach.
(*f*) Tests completed; final report in preparation.
(*g*) The ladder developed in the model study has 29 pools that are connected by vertical slots that provide fish passage between the entrance and a false weir with exit chute to the upstream basin. Velocities in the slots ranged from 1.1 to 7.2 fps. No upwelling that might attract or trap fish occurred along walls or in corners. Velocities over the false weir were between 4.1 and 4.9 fps, downstream discharge of the weir was 14 to 15 cfs, and discharge to the chute was 1.23 to 2.48 cfs. Attraction flow from the entrance penetrated 50 to 60 ft into tailwater.

313-09347-350-00

MODEL STUDY OF OUTLET WORKS FOR ELK CREEK DAM, ROUGE RIVER BASIN, OREGON

(*b*) U.S. Army Engr. Dist., Portland.
(*d*) Experimental; for design.
(*e*) The project will be located on Elk Creek, 1.7 miles upstream from the Rouge River and 27 miles north of Medford, Oregon. The dam will be a 238-foot-high rockfill embankment with a concrete gravity spillway and a twin-conduit outlet tunnel with a flip bucket dissipator. The tunnel is to pass a discharge of 7,200 cfs. The outflow of the flip bucket, the size of the plunge pool, and an adult fish collection facility entrance were studied in a 1:40-scale model.
(*f*) Tests completed; final report in preparation. Tests were terminated when design of the project was deferred because of environment problems.
(*g*) The outflow of the flip bucket was satisfactory, and the plunge pool was a minimum size for satisfactory velocities along the excavated sides. The proposed fish collection entrance at the side of flip bucket was not satisfactory; reverse flow occurred in the approach path with some modes of outlet operation. Preliminary tests indicated an entrance in the upstream corner of the plunge pool would be satisfactory; however, testing was terminated before a complete study was made.

313-09348-350-00

GENERAL MODEL STUDY OF CHIEF JOSEPH DAM, COLUMBIA RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Seattle.
(*d*) Experimental; for design.
(*e*) See 313-07109 for description of project. The study was made to determine the effects of spillway deflectors and ultimate 27-unit powerhouse on flow conditions in the tailrace. A section of forebay, the 19-bay spillway with piers and gates for the pool raised 10 ft to elevation 956 (bays 36 ft wide instead of as-built 40-ft bays), downstream side of 27-unit powerhouse, and tailrace to the mouth of Foster Creek were reproduced in a 1:72-scale model.
(*f*) Tests completed; final report in preparation.
(*g*) Velocities, wave heights, water-surface elevations, and overall flow conditions were observed with uniform and nonuniform spillway gate openings. River discharges of 190,000 to 1,200,000 cfs and operation of 0, 9, 18, and 27 powerhouse units were studied. With 12.5-ft-wide deflectors at elevation 775 (see separate report), wave rideup along the banks and wave heights at the powerhouse created by the deflectors was reduced by nonuniform openings of the spillway gates.

313-09349-350-13

MODEL STUDY OF SPILLWAY DEFLECTORS FOR CHIEF JOSEPH DAM, COLUMBIA RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Seattle.
(*d*) Experimental; for design.
(*e*) See 313-07109 for description of project. The purpose of the study was to develop a flow deflector to produce stable "skimming flow" instead of plunging flow in the stilling basin, thereby reducing nitrogen supersaturation downstream from the spillway. A four-bay, 1:43.35-scale sectional model reproduced the existing stilling basin, exit channel, and spillway agee. The piers and gates were for the raised pool, elevation 956, with 36-ft-wide bays, rather than with as-built 40-ft bays.
(*f*) Tests completed; final report in preparation.
(*g*) A 12.5-ft-wide deflector at elevation 775 on the spillway chute provided the best overall performance. Skimming flow existed up to 14,000 cfs per bay with tailwater for 27-unit powerhouse operation, 10,000 cfs with 18-unit operation, and 6,500 cfs per bay with the powerhouse closed. Either surging or plunging flow occurred above these limits. Surging flow may increase wave action along the downstream side of the powerhouse. Deflectors on piers adjacent to ends of spillway were required to minimize overtopping of training walls. Tests of the entire structure were made in a 1:72-scale model (see separate report).

313-09350-350-13

MODEL STUDY OF SPILLWAY DEFLECTORS FOR LITTLE GOOSE DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 313-04504 for description of project. Deflectors on the spillway just below tailwater were developed to reduce deep air entrainment in the outflow and nitrogen supersaturation downstream from the spillway. A three-bay section of upstream approach, spillway, and exit channel were reproduced in a 1:42.47-scale model.
(*f*) Test completed; final report in preparation.
(*g*) Four deflector widths and three elevations were studied, and the width and location that performed best with

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discharges from 4,700 to 106,250 cfs per bay was selected. Effects of the deflector on flow conditions downstream from the dam, especially on adult fish passage, were studied in a 1:50-scale general spillway model (see separate report).

313-09351-350-13

MODEL STUDY OF SPILLWAY DEFLECTORS FOR MCNARY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) The existing project, located about 2.5 miles upstream from Umatilla, Oregon, includes a 22-bay spillway, a 14-unit powerhouse, an 86-ft by 675-ft navigation lock with maximum single lift of 92 ft, and facilities to pass migratory fish upstream over the dam. Flow under or between upper and lower halves of the vertical-lift spillway gates carries entrained air deep into the stilling basin. This results in excessive amounts of dissolved gases (chiefly nitrogen) that are harmful to fish downstream from the project. The purpose of the tests was to develop a means of spilling flood waters without increasing nitrogen supersaturation. A 1:40-scale model reproduced a three-bay section of the forebay, spillway, stilling basin downstream from bays 1 to 19, and exit channel.
(*f*) Completed; final report in preparation.
(*g*) Air penetration, flow stability, and current directions in the stilling basin, and pressures were determined with and without deflectors. Flow was passed underneath or between upper and lower sections of the gates. Spillway discharges of 13,500 cfs and less per 50-ft bay were of primary concern. Without deflectors, flow for either method of gate operation plunged to the floor of the stilling basin; highly aerated water was distributed uniformly throughout the basin. With 12.5-ft-long horizontal deflectors at elevation 256 and discharge beneath the gates, stable "skimming flow" (with air bubbles confined to the top layer of water) occurred for an 8-ft range in tailwater elevations (257 to 265). Deflectors 20 ft long at elevation 256 were required when flow was passed between gate sections. Additional tests, with deflectors on the spillway chute, will be made in a general spillway model.

313-09352-350-13

MODEL STUDY OF OUTLET FOR MOOSE CREEK DAM, CHENA RIVER LAKES PROJECT, ALASKA

(*b*) U.S. Army Engr. Dist., Alaska.
(*d*) Experimental; for design.
(*e*) Moose Creek Dam, to be located on the Chena River about 17 miles east of Fairbanks, Alaska, will have an average height of about 30 ft and will have an overall length of 7.1 miles. The earthfill dam will divert Chena River flood waters into the Tanana River and provide non-damaging flows in the existing Chena River channel. A proposed outlet channel with riprapped bottom 80 ft wide and riprapped side slopes of 1V on 2H will divert the river from its natural channel upstream of the dam, through the outlet structure, and back to the river downstream from the dam. The outlet works was sized to pass river flows up to 9,000 cfs, small recreation boats, and fish underneath four 25- by 18-ft vertical-lift gates. Two fishways and a fish ladder are proposed for use when velocities through open gate bays exceed 2.5 fps and when flows are being regulated. The purposes of the model study are to check hydraulic performance of the proposed design and to develop revisions if required.
(*f*) Tests completed; final report in preparation.
(*g*) A shallow stilling basin with baffles and a sloping end sill were developed in single-bay, 1:20-scale model. The four-bay outlet structure with fishways and a fish ladder entrance was studied in a 1:40-scale model. The outlet and fishways were satisfactory. The outlet piers were shortened at the downstream end. The upstream approach channel to the outlet was lengthened to produce adequate hydraulic drop between the natural river and the outlet with ungated flows.

313-10658-350-13

GENERAL MODEL STUDY OF SPILLWAY OF LOWER MONUMENTAL DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) Lower Monumental Dam is located on the Snake River at mile 41.6 about 32 miles from Ice Harbor Dam. Principal features include a six-unit powerhouse, a 103-foot single lift navigation lock, an eight-bay spillway, and two fish ladders. The spillway was studied in a 1:50-scale general model of the project to determine the effects of flow deflectors on flow conditions at adjacent fishway entrances and to develop an operation schedule for optimum conditions for fish passage.
(*f*) Tests completed; final report in preparation.
(*g*) Satisfactory flow conditions for fish passage and reduction of nitrogen supersaturation were obtained with flow deflectors in five, six, and eight bays of the spillway. An optimum spillway operation schedule was developed.

313-10659-350-13

GENERAL MODEL STUDY OF SPILLWAY OF MCNARY DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 313-09351 for description of project. The spillway was studied in a 1:50-scale general model of the project to determine the effects of flow deflectors on flow conditions at adjacent fishway entrances and to develop an operation schedule for optimum conditions for fish passage.
(*f*) Tests completed; final report in preparation.
(*g*) Satisfactory flow conditions for fish passage and reduction of nitrogen supersaturation were obtained with flow deflectors in all but the end bays of the spillway. An optimum spillway operation schedule was developed.

313-10660-350-13

GENERAL MODEL STUDY OF SPILLWAY OF LITTLE GOOSE DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 313-04504 for description of project. The spillway was studied in a 1:50-scale general model of the project to determine the effects of flow deflectors on flow conditions at adjacent fishway entrances and to develop an operation schedule for optimum conditions for fish passage.
(*f*) Tests completed; final report in preparation.
(*g*) Satisfactory flow conditions for fish passage and reduction of nitrogen supersaturation were obtained with flow deflectors in all but the end bays of the spillway. Poor fish passage conditions occurred when flow was spilled uniformly from all bays. An optimum spillway operation schedule of nonuniform spills was developed.

313-10661-350-13

GENERAL MODEL STUDY OF SPILLWAY OF ICE HARBOR DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Walla Walla.
(*d*) Experimental; for design.
(*e*) See 313-08445 for description of project. The spillway was studied in a 1:50-scale general model of the project to determine the effects of flow deflectors on flow conditions at adjacent fishway entrances and to develop an operation schedule for optimum conditions for fish passage.
(*f*) Tests completed; final report in preparation.
(*g*) Satisfactory flow conditions for fish passage and reduction of nitrogen supersaturation were obtained with flow deflectors in six, eight, or ten bays of the spillway. An optimum spillway operation schedule of nonuniform spills was developed.

313-10662-350-13

MODEL STUDY OF SPILLWAY DEFLECTORS FOR JOHN DAY DAM, SNAKE RIVER, WASHINGTON

(*b*) U.S. Army Engr. Dist., Portland.
(*d*) Experimental; for design.
(*e*) See 313-07114 for description of project. Deflectors on the spillway just below tailwater were developed to reduce deep air entrainment in the outflow and nitrogen supersaturation downstream from the spillway. A three-bay section of upstream approach, spillway, and exit channel were reproduced in a 41.14-scale model.
(*f*) Test completed; final report in preparation.
(*g*) Three deflector widths and four elevations were studied with two configurations of downstream topography, and the optimum width and elevation were selected for discharges of 3,000 to 19,300 cfs per bay. Effects of the deflector on flow conditions downstream from the dam, especially on adult fish passage, will be studied in a 1:50-scale general spillway model.

313-10663-850-13

TEST OF FISH SCREENS

(*b*) U.S. Army Engr. Div., North Pacific, Hydro-Electric Design Branch.
(*d*) Experimental; for design.
(*e*) Rotating fish screens are utilized in intakes of powerhouses on the Columbia and Snake Rivers to divert fingerling fish into an intake gate well where they are channeled around the turbines to the tailrace. Little hydraulic data were available for the steel mesh screen in use, and none was available for new plastic meshes being proposed for use. Hydraulic characteristics of flow through four types of mesh with various arrangements of perforated metal plate behind them were observed in a 14.6- by 16-inch water tunnel.
(*f*) Completed.
(*g*) With steel mesh and three plastic mesh screens and various arrangements of perforated metal plates behind them the head drop across the screens and the pull-away force of a simulated fingerling were determined for four approach velocities. The pull-away forces were for comparative use only.

313-10664-330-13

MODEL STUDY OF NAVIGATION CHANNEL IMPROVEMENTS, BONNEVILLE DAM, COLUMBIA RIVER, OREGON AND WASHINGTON

(*b*) U.S. Army Engr. Dist., Portland.
(*d*) Experimental; for design.
(*e*) See 313-07107 for description of the project and the model. The study was made to determine the effect of a new navigation lock location, enlargement of certain narrow reaches of channel, and a new moorage location on the ability of tows and barges to navigate at Bonneville Dam.
(*f*) Scheduled tests completed; other tests might develop.
(*g*) Two new navigation lock sites on the Oregon shore near the existing lock have been found satisfactory for navigation. Excavation of a portion of Bradford Island in the forebay enlarges the entrance to the forebay and greatly improves tow maneuverability. A new moorage in the forebay coupled with excavation of a portion of Bradford Island greatly aids navigation with the existing lock. A proposed spur dike extending upstream from the excavated section of the island did not improve fish passage conditions.

313-10665-850-13

CALIBRATION OF MODEL "A" ALASKA STEEPPASS FISH LADDER

(*b*) U.S. Army Engr. Dist., Alaska.
(*d*) Experimental; for field operation.
(*e*) The model "A" Alaska steeppass fish ladder is a denil-type ladder with side and bottom vanes developed by the Alaska Department of Fish and Game. The study was made to determine the hydraulic characteristics of the ladder when inclined at slopes less than 15 percent and to determine the feasibility of using the ladder in field tests of passage of Arctic grayling.
(*f*) Completed.
(*g*) Observations indicated that the steeppass fish ladder on a mild slope would have the desired flow characteristics for passage of Arctic grayling and would be suitable for field tests. A slope of 7.5 percent had the best characteristics. The results extended the hydraulic data previously published by Alaska Department of Fish and Game, Informational Leaflet No. 12, April 27, 1962.
(*h*) **Alaska Steeppass Model "A" Fish Ladder,** *Memo. Rept. No. 1*, Div. Hydr. Lab., Oct. 4, 1976.

313-10666-350-13

MODEL STUDY OF SPILLWAY FOR LIBBY REREGULATING DAM, KOOTENAI RIVER, MONTANA

(*b*) U.S. Army Engr. Dist., Seattle.
(*d*) Experimental; for design.
(*e*) See 313-09345 for description of project. The spillway and the intake and outlet for a bulb turbine of a hydrocombine structure are to be developed in a three-bay model. Preliminary development of the spillway section is to be made in a one-bay, 1:50-scale model.
(*g*) Hydraulic characteristics of two spillway shapes have been determined for preliminary design.

313-10667-210-13

CALIBRATION OF PIT ORIFICES AND SERVICE LOOP FOR DOMESTIC WATER SYSTEMS IN ALASKA

(*b*) U.S. Army Engr. Dist., Alaska.
(*d*) Experimental, for design.
(*e*) Pairs of pit orifices 3/4, 1, and 1-1/4 inch in diameter inserted in a 6-inch water main and connected to 25-foot-long service loops of the same size as the pit orifice were tested to determine the head loss in the main due to the orifice, the head drop through the loop, and the water velocity in the loop with various velocities in the main. The data were to be used in determining head loss and heat exchange.
(*f*) Completed; memorandum report in preparation.
(*g*) Head loss in the 6-inch main, head drop through the 25-foot loop, and velocities in the loop were determined for three pit orifice and loop sizes with 2- and 4-fps velocities in the main.

DEPARTMENT OF THE ARMY, WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS, P.O. Box 631, Vicksburg, Miss. 39181. F. R. Brown, Engineer, Technical Director.

These project summaries are abridged from more detailed descriptions appearing in the FY 1977 Civil Works Annual Research Summary, Vols. 1 and 2, Office of the Chief of Engineers, Washington, D. C. 20314.

314-06849-400-13

MODEL STUDY OF CHESAPEAKE BAY

(*b*) Baltimore District, North Atlantic Division.
(*c*) David Bastian, Estuaries Branch.
(*e*) The Estuaries Branch has been given the responsibility for assisting the Baltimore District in the design, construction, verification, and testing of a hydraulic model of the Chesapeake Bay. The model will be utilized to develop a water-land management plan for use of the Chesapeake Bay and tributaries. A fixed-bed, comprehensive model of the Chesapeake Bay and tributaries with linear scale ratios of 1:100 vertically and 1:1000 horizontally will be constructed. The model will have the capability of reproducing tides, current velocities, salinities, hurricane surges, and freshwater inflows.

314-06859-330-13

MODEL STUDY OF SMITHLAND LOCKS AND DAM

(*b*) Ohio River Division, Nashville.
(*c*) B. K. Melton.
(*e*) Determine the suitability of the location of proposed locks and dam from a navigation standpoint and to develop plans for the elimination or reduction of shoaling in approach channels. The study was conducted on a 1:150-scale model extending from river mile 916.5 to 925.0 which was convertible from fixed bed for navigation studies to coal bed for channel development studies.
(*g*) The study has resulted in the development of plans that would provide satisfactory conditions in both upper and lower lock approaches and in the dredged navigation channel downstream. Plans also have been developed that would reduce or eliminate shoaling in the lower lock approach and in the dredged navigation channel downstream. The model has been rehabilitated to test bank scouring below the Cumberland River with the cofferdam in place and to test the stability of the cofferdam cells which will become a part of the fixed weir section of the dam. Bank scouring tests have been completed and the test results in preliminary form have been forwarded to the District.

314-07171-470-13

INVESTIGATION OF SHOALING AT HARBOR ENTRANCES

(*b*) Lower Mississippi Valley Division.
(*c*) B. K. Melton.
(*e*) Conduct a study of shoaling at harbor entrance in alluvial streams under laboratory conditions to determine corrective measures to be taken at St. Louis, Mo., Greenville, Miss., and Lake Providence, La. The study was conducted in a movable-bed model in which the harbor entrances were modified to fit existing conditions or in accordance with proposed plans.
(*h*) Report in process.

314-09663-820-13

ANALYSIS OF ARBITRARY WELL SYSTEM

(*b*) Lower Mississippi Valley Division.
(*c*) J. B. Warriner.
(*e*) Formalize the results as have been previously obtained from electrical analog model studies into a computer program, accompanied by example problems and a fully documented user guide, that can give the designer the capability of predicting flow and drawdown associated with fully and partially penetrating wells placed arbitrarily within irregular boundaries. This work is being performed to aid in the design of numerous construction dewatering systems for projects in LMVD. A complete review of the results previously obtained for single wells will be performed, followed by an extension of the results to multiple well systems. An existing computer will be modified to include the results of the review and then used to check specially designed electrical analog tests.
(*g*) A technique has been devised for calculating discharges from wells of random spacing and different locations.
(*h*) Report in preparation.

314-09666-830-13

LEVEE WAVE WASH PROTECTION

(*b*) Lower Mississippi Valley Division.
(*c*) C. R. Styron, III.
(*e*) To determine the effectiveness of a dust control system as a temporary protective cover for soil embankments subject to wave wash. A silty clay soil was placed in a wave flume and compacted with the soil surface sloping one vertical to three horizontal. The dust control system (DCA-1295, a polyvinyl acetate liquid, reinforced with fiberglass scrim) was applied at three different rates and tested against wave-action forces. Six other liquid materials were also tested, and these materials compared with a prefabricated neoprene-coated nylon membrane.
(*f*) Completed.
(*g*) It was concluded that the dust control system and AC-8 asphalt cement gave a little better overall performance than did the other liquid materials but that none of these would provide any appreciable protection against wave wash for any considerable length of time. The prefabricated membrane material performed in a satisfactory manner without any damage when subjected to wave wash action for a period of four hours. Indications were that the membrane would have continued to water proof and protect a soil embankment for an indefinite period. It was concluded that this membrane, or a similar fabric, when properly anchored to a soil embankment would provide wave wash protection. A report in the form of a Memorandum for Record was reviewed in the S&PL and forwarded to the sponsor 5 May 1976.

314-09667-330-13

LOCK AND DAM 26, MISSISSIPPI RIVER

(*b*) Lower Mississippi Valley Division.
(*c*) L. J. Shows.
(*e*) Determine whether the existing structure should be modernized by adding an additional lock or whether a new structure should be provided. A model study is being conducted which encompasses the reach between river miles 199.0 and 205.7 on the Mississippi River, and the model is built to an undistorted scale of 1:120. The model is of the fixed-bed type reproducing locks and dam structures and adjacent overbank area between the levees.
(*f*) Tests completed.

314-09670-300-13

MISSISSIPPI RIVER PASSES MODEL STUDY

(*b*) New Orleans District; Lower Mississippi Valley Division.
(*c*) G. M. Fisackerly.
(*e*) Investigate plans for the reduction of shoaling in the existing 40-ft channel and determine the feasibility of a deeper channel. A fixed-bed model reproduces the Mississippi River downstream from 14 miles above Head of Passes, including South and Southwest Passes and portions of Pass a Loutre and Cubits Gap and a segment of the Gulf of Mexico. Model scales are 1:100 vertically and 1:500 horizontally. Fixed-bed shoaling tests using artificial sediments will be used to evaluate improvement plans.
(*g*) Hydraulic adjustment of the model and shoaling verification of the Head of Passes area have been completed. Base shoaling tests and tests of dredging methods have been completed. Tests of plans to reduce shoaling at Head of Passes with the existing channel depth have also been completed. Tests to assure proper reproduction of hydraulic phenomena and salinity intrusion in Southwest Pass have been completed. Tests to obtain a shoaling verification of Southwest Pass below Head of Passes are currently under way. Additional plan tests have been requested by the district.

314-09671-330-13

MODEL STUDY OF ALEXANDRIA REACH, RED RIVER

(*b*) Lower Mississippi Valley Division.
(*c*) L. J. Shows.
(*e*) Determine the modification required to bridges in the reach and the type and location of regulating structures required to develop a satisfactory navigation channel through the reach. An undistorted fixed-bed model has been constructed to a scale of 1:100, model to prototype. The model encompasses about four miles of the river channel including the five bridges through the reach as well as adjacent overbank areas between levees.
(*f*) Tests completed.

314-09672-330-13

MODEL STUDY OF EMERGENCY BULKHEAD CLOSURE, MISSISSIPPI RIVER GULF OUTLET LOCK

(*b*) Lower Mississippi Valley Division.
(*c*) J. H. Ables, Jr.

(*e*) Study design details and the plan for emergency closure of the 150-ft-wide and 1200-ft-long lock. A 1:50-scale model will be used to reproduce the entire chamber and an appropriate length of canal at each end. The bulkheads will be reproduced accurately to scale, size, shape, and weight. One pair of miter gates may be accurately reproduced to scale so that the possibility of their use for emergency closure can be tested. Model tests will be concerned with determining loads acting on the closure during emergency placement. The problem will be unusual due to the width of the lock being 40 ft greater than closures previously studied.

314-09673-330-13

MODEL STUDY OF FILLING AND EMPTYING SYSTEM FOR MISSISSIPPI RIVER-GULF OUTLET LOCK

(*b*) Lower Mississippi Valley Division.
(*c*) J. H. Ables, Jr.
(*e*) Develop a side wall port filling and emptying system for lockage of both barge and ship traffic. All elements of the system must be adequate under normal and reverse head conditions common to the proposed site. A 1:25-scale physical model that reproduces portions of the upper and lower approaches and the entire filling and emptying system is being used for study and evaluation of performance of the proposed 150-ft-wide and 1290-ft-long lock chamber. Barge tows and ships of variable drafts are simulated as well as the usual culvert valve control equipment and instrumentation to measure hawser forces.
(*g*) Tests completed on side port system.

314-09674-350-13

MODEL STUDY OF MERAMEC PARK RESERVOIR OUTLET WORKS

(*b*) Lower Mississippi Valley Division.
(*c*) B. P. Fletcher.
(*e*) To develop an adequate stilling basin design and determine the size and extent of stone protection required for the exit channel.
The scales of the model were changed to conform with the change in conduit size (22-ft wide reduced to 14-ft wide) specified by the District. Tests were conducted in a 1:25.5-scale model in which a 160-ft-wide and 260-ft-long approach area, the intake structure, transition, conduit, stilling basin, and 650 ft of exit channel were reproduced.
(*f*) Tests complete. Report in progress.

314-09676-350-13

MODEL STUDY OF RED RIVER SPILLWAYS NOS. 1 AND 2

(*b*) Lower Mississippi Valley Division.
(*c*) N. R. Oswalt.
(*e*) Assist in design of the subject spillways and determine the size and extent of downstream riprap protection required with single-gated operations. A 1:36-scale hydraulic model reproducing about 600 ft of the approach area, the full width of spillway, and 1400 ft of the exit channel was used to evaluate and refine the proposed designs.
(*f*) Tests complete. Reports in progress.

314-09677-330-13

MODEL STUDY OF SHOALING IN SAWYER BEND AND ENTRANCE TO CHAIN OF ROCKS CANAL (MISSISSIPPI RIVER)

(*b*) Lower Mississippi Valley Division.
(*c*) J. E. Foster.
(*e*) Investigate various plans to eliminate shoaling in Sawyer Bend and improve shoaling conditions in the lower entrance to Chain of Rocks Canal. A movable-bed model with scale ratios of 1:250 horizontally and 1:100 vertically reproducing the Mississippi River from about river mile 169.0 to 190.8 is being used for the study.
(*g*) Plans have been developed to eliminate shoaling in Sawyer Bend and reduce shoaling in the entrance to Chain of Rocks Canal. Tests indicated Phase I of the construction program would be effective in improving shoaling in Sawyer Bend. Testing has been completed and preliminary results furnished the District. Data are being prepared for inclusion in the final report.

314-09680-350-00

OLD RIVER DIVERSION MODEL STUDY

(*b*) Lower Mississippi Valley Division.
(*c*) T. J. Pokrefke.
(*e*) Obtain data to permit development of plans for the repair of damages that occurred to the low-sill structure during the 1973 flood and to aid in the selection of a site for another low-sill structure. Initially the study was conducted on a 1:120 scale, fixed-bed model from Mississippi River mile 313.0 to 318.5. Subsequently, the model was extended downstream to mile 306.0.
(*g*) Tests requested by the District on the existing structures and channel with the August 1973 conditions have been completed. Tests of proposed rock weirs and of a series of piling in the ouflow channel to control the distribution of flow through the existing structures and to insure the continued security of the low sill structure have been completed. Inflow channel improvement tests have been completed. Tests have been undertaken on a barge barrier to reduce the possibility of loose barges entering the inflow channel. Tests to provide data for the proposed Operation and Maintenance Manual are being conducted intermittently as time permits.

314-09681-330-13

RED RIVER WATERWAY, LOCK AND DAM NO. 1 MODEL STUDY

(*b*) Lower Mississippi Valley Division.
(*c*) J. E. Foster.
(*e*) Investigate alignment problems and the effectiveness of training works needed to satisfy navigation conditions and requirements in the vicinity of the proposed cutoff and lock. A movable-bed model with scale ratios of 1:120 horizontally and 1:30 vertically reproducing about five miles of the Red River in the vicinity of the proposed Lock and Dam is being used for the study.
(*g*) Fixed-bed tests have been conducted to check navigation conditions at the entrance to the lock at the proposed location. The model has been converted to movable bed and tests are being conducted to ascertain the channel development to be expected upon construction of the lock and dam and what channel structures will be needed in the area.

314-09682-300-13

REHABILITATION OF MISSISSIPPI BASIN MODEL, INCLUDING VERIFICATION TO 1973 CONDITIONS, AND INITIAL TESTING RELATIVE TO PROJECT FLOOD

(*b*) Lower Mississippi Valley Division.
(*c*) J. E. Foster.
(*e*) Rehabilitate the portion of the Mississippi Basin Model from Hannibal to Baton Rouge in preparation for future testing and verify to 1973 stage-discharge relationships and to conduct initial tests of the Mississippi River and Tributaries Project Design Flood.
(*g*) The model has been verified to the 1973 Flood except for the Atchafalaya River Basin and tests of the Mississippi River Project Design Flood have been initiated.

314-09684-350-13

RIGOLETS CONTROL STRUCTURE

(*b*) New Orleans District; Lower Mississippi Valley Division.
(*c*) R. A. Boland, Jr.
(*e*) Determine the adequacy of the design for the flow control structures in the hurricane surge protection barrier across the Rigolets at the original and alternate locations. The tests will be conducted on a fixed-bed model constructed to an undistorted scale of 1:100 with an area of about

22,000 sq. ft. The model will be equipped with the necessary pumps, pipes, and valves to establish steady-state flow regimes in either the flood or ebb direction with equipment required to measure water-surface elevations and velocities.

(*f*) Completed.

(*h*) **Hydraulic Characteristics of Rigolets Pass, Louisiana, Hurricane Surge Control Structures,** *TR H-76-16*, Sept. 1976.

314-09685-070-13

SEEPAGE MODEL STUDIES

(*b*) Lower Mississippi Valley Division.

(*c*) C. L. McAnear.

(*e*) Develop experimental and numerical techniques to obtain solutions to some of the more complex seepage problems encountered within the Lower Mississippi Valley Division. A three-dimensional electrical analogy model will be used to solve underseepage problems and a viscous flow model will be used to solve transient groundwater flow problems. Numerical techniques will be developed for analysis of fluid flow through soils on the basis of the finite difference and finite element methods.

(*h*) **Finite Element Method of Analysis and Design of Banks Subjected to Seepage, C. S. Desai,** Aug. 1976.

314-09686-300-13

LITTLE BLUE RIVER CHANNEL IMPROVEMENT MODEL STUDY

(*b*) Kansas City District.

(*c*) B. Brown.

(*e*) Develop design data for the resistance caused by (1) shear interface caused by addition of berms to low flow channels, (2) low flow channel crossing from side to side in the main channel, (3) resistance to bends, and (4) resistance caused by trees and other plantings. The model is constructed in a 5-foot wide by 96-foot long tilting flume. Tests will be conducted to develop normalized rating curves for each cross-section and to define energy losses as a function of channel geometry. Representative velocity determinations are being obtained for the various channel configurations.

(*f*) Report in preparation.

314-09687-470-13

NEWBURYPORT HARBOR MODEL STUDY

(*b*) New England Division.

(*c*) N. J. Brogdon, Jr.

(*e*) Investigate proposed plans and/or modifications to existing projects in an effort to determine their effects on channel shoaling in the harbor entrance, small boat navigation, erosion of Plum Island Point, existing salinity conditions, and water quality. A combination fixed-bed and movable-bed model has been constructed, which includes a portion of the Atlantic Ocean, Newburyport Harbor, and the Merrimack River to head of tide. Linear scales are 1:100 vertically and 1:300 horizontally. The model is equipped to reproduce tides, tidal currents, wave action, density currents, and freshwater inflows.

314-09692-430-13

JAMAICA BAY HURRICANE SURGE STUDY

(*b*) New York District; North Atlantic Division.

(*c*) R. F. Athow, Jr.

(*e*) Develop a barrier plan that will prevent flooding within the bay and associated lowlands during periods of northeasterly winds or hurricanes, and to determine the effects of the plan on tides, velocities, salinities and dye concentrations within Jamaica Bay, and navigation, and to improve circulation and water quality in the bay by developing the required design and operating procedure for the tidal passages in the barrier and, if necessary, developing the design for training dikes and/or channel improvements. The comprehensive fixed-bed model of New York Harbor, with linear scale ratios of 1:1000 horizontally and 1:100 vertically, is being used for the physical model of Jamaica Bay study. This will be augmented by construction of an undistorted section of the selected barrier to solve erosion problems and operating techniques. A model developed as a separate study by Dr. Leendertse (Rand Corporation) is being used for the mathematical model.

(*f*) Completed.

(*h*) **Effects of Hurricane Surge Barrier on Hydraulic Environment, Jamaica Bay, N.Y.,** *Final Technical Report H-76-14*, Sept. 1976.

314-09701-330-13

BAY SPRINGS CANAL SURGE STUDY

(*b*) Ohio River Division, Nashville.

(*c*) J. P. Bohan.

(*e*) Determine the effect of the releases from Bay Springs Lock on Navigation in the relatively small canal below the lock. A 1:80-scale model of 4000 ft of canal below the Bay Springs will be constructed. The lock release hydrograph will be simulated using electrically automatic equipment. Water level detectors will be used to plot surge heights. Strain gages will be used to instrument a model tow while moored at various locations in the canal.

(*f*) Tests complete. Report in progress.

314-09702-330-13

MODEL STUDY OF FILLING AND EMPTYING SYSTEM FOR BAY SPRINGS LOCK, TENN-TOMBIGBEE WATERWAY

(*b*) Ohio River Division.

(*c*) J. H. Ables, Jr.

(*e*) Develop a longitudinal floor culvert filling and emptying system for a 110-ft by 600-ft lock with a maximum head of about 84 feet. The model will reproduce the entire filling and emptying system and short portions of the approaches at a scale of 1:25. Usual instrumentation will be provided.

(*f*) Tests completed.

314-09703-350-13

CHUTE DISSIPATOR MODEL STUDY IN DIVIDE CUT, TENN-TOM WATERWAY

(*b*) Ohio River Division.

(*c*) J. H. Ables, Jr.

(*e*) The four major drainage structures or baffled chutes will be designed to accommodate 50-year frequency discharges, and the height of sidewalls will be increased in an attempt to contain the 100-year flows. The side slopes of the Divide Cut will also be established. Because the proposed slopes of the chute dissipator have not been tested or reported and the magnitude of unit discharge is at the upper end of available data for other slopes, a model study was recommended. The study of the chute energy dissipators is being conducted in a 1:25-scale model including approximately 300 ft of the approach channel, the transition to the 168-ft-wide chute, the energy dissipator and stilling pond, and a section of the canal approximately 600 by 275 feet.

(*g*) In an effort to simplify the structural design, a hydraulic jump type stilling basin that produced satisfactory energy dissipation immediately downstream from the structure was developed for the major drainage structure. However, the velocities at a depth of 6 feet entering the canal were not equally distributed. As a result, baffle blocks were placed on the chute to simulate the baffled chute spillway design shown in GDM No. N-1 for these structures. The height of the sidewalls on the chute was increased from 11 feet to 12 feet in order to contain the design flow of 9700 cfs within minimum canal stage at elevation 408. The stilling pool was reduced from a constant width of 250 feet (original design) to 168 feet at the end of the chute walls and to 240 feet at the canal. The optimum shape and limits of riprap were determined. Although the other three major structures will have different widths, they should be proportioned geometrically the same as the structure that was tested.

314-09704-350-13

SPLITTER WALL DISSIPATOR MODEL STUDY IN DIVIDE CUT, TENN-TOM WATERWAY

(*b*) Ohio River Division.
(*c*) J. H. Ables, Jr.
(*e*) Due to the unusual nature of the splitter wall basin and the problems that may be encountered with the hydraulic jump in the closed conduit upstream from this basin, a model study was recommended. The dissipator located in the floor of the canal may be a potential source of trouble during maintenance dredging. The study of the splitter wall is being conducted in a 1:10-scale model that reproduces three exit channels downstream from the Type VI basins, a portion of the connecting channel, the entrance transition, the chute, the splitter wall basin, and a portion of the canal approximately 200 by 140 feet. The hydraulic characteristics of the structures are not readily determined by mathematical analyses and will be determined by model tests.
(*g*) Calibration data were obtained with various lengths and depths of the drop structure. These data for the recommended design were furnished as ratios of the width of the chute so that the dimensions of the structures can be determined for a known discharge and allowable head. All data were obtained with an abutment radius equal to three times the width of the chute. The splitter wall energy dissipator of the original design was replaced with a hydraulic jump type energy dissipator which was recommended for use at the downstream end of the chutes where flow enters the navigation energy dissipator where flow enters the canal.

314-09707-430-13

MODEL STUDIES OF OREGON INLET, NORTH CAROLINA

(*c*) Dr. C. L. Vincent.
(*e*) To determine optimal plan of improvement to stabilize the navigation channel through the inlet by testing proposed plans of improvement in a physical model. To determine jetty stability damage as a function of increasing storm waves (breaking waves) in excess of the design wave.
A physical model of Oregon Inlet and adjacent areas of Pamlico Sound has been constructed to scales of 1:300 horizontally and 1:60 vertically. Various plans of improvements will be tested. The testing includes measurements of tidal elevations and velocities, surface photographs, wave heights, and movable-bed shoaling/scouring.
Typical two-dimensional cross sections and three-dimensional head sections of rock and dolos armor are being model tested using maximum breaking waves (depth limited) to determine the amount of damage that will occur for waves (and water depths) that exceed the design condition.
(*g*) Verification of the physical model is essentially complete.

314-09717-300-13

MODEL STUDY OF SUCK BEND, CHATTAHOOCHEE RIVER

(*b*) Mobile District.
(*c*) J. E. Glover.
(*e*) Develop plans to reduce or eliminate shoaling in Suck Bend; Chattahoochee River. A movable-bed hydraulic model reproducing a section of the river from navigation mile 73.0 to 74.4 to an undistorted scale of 1:72 was used to study the problem.
(*f*) Tests complete.
(*g*) A plan which would reduce shoaling and provide a satisfactory navigation channel through the reach has been developed.

314-09719-330-13

MODEL STUDY OF ALICEVILLE LOCK AND DAM, TENN-TOM WATERWAY

(*b*) Mobile District.
(*c*) L. J. Shows.
(*e*) Study navigation conditions in the lock approach and current conditions in the diversion canal during construction of the lock and dam. The model is of the fixed-bed type constructed to an undistorted scale of 1:100, reproducing about three miles of the Tombigbee River Channel near Pickensville, Alabama, Lock and Dam diversion canal and adjacent overband areas.
(*g*) All scheduled testing has been completed. Analysis of the results of completed tests has been undertaken. Satisfactory navigation conditions can be developed in both the upstream and downstream lock approaches at the proposed site.

314-09721-330-13

MODEL STUDY OF COLUMBUS LOCK AND DAM, TENN-TOM WATERWAY

(*b*) Mobile District.
(*c*) L. J. Shows.
(*e*) Determine flow conditions and their effects on navigation and develop modifications in the plan that might be considered desirable for the complex arrangement of the various channels and diversions. A fixed-bed model was constructed to an undistorted scale of 1:120. The model reproduces the Tombigbee River Channel from about 8,000 ft downstream to about 18,000 ft upstream of the dam, about 10,000 ft of the lower Tibee River Channel, pertinent adjacent overbank areas, and the lock and dam and navigation canals.
(*f*) Complete.
(*g*) All scheduled testing has been completed. Analysis of the results of completed tests has been undertaken. Satisfactory navigation conditions can be developed in both the upstream and downstream lock approaches at the proposed site.

314-09722-330-13

MODEL STUDY OF ABERDEEN LOCK AND DAM, TENN-TOM WATERWAY

(*b*) Mobile District.
(*c*) L. J. Shows.
(*e*) Develop plans which will provide good navigation conditions in the lock approaches and minimize the adverse effects of the left overbank flow on tows moving through the navigation channel during high stages. The model is of the fixed-bed type, constructed to an undistorted scale ratio of 1:120, and reproduces a short reach of the Tombigbee River upstream and downstream of the dam, the approach channel to the lock, the lock and dam structure, and the adjacent overbank areas.
(*f*) Tests complete. Report in preparation.
(*g*) Satisfactory navigation conditions can be developed in both the upstream and downstream lock approach at the proposed location. The effects of the cofferdam on flood flow stages would be minor and the effects on current velocities would be local.

314-09723-330-13

MODEL STUDY OF GAINESVILLE LOCK AND DAM, TENN-TOM WATERWAY

(*b*) Mobile District.
(*c*) L. J. Shows.
(*e*) Investigate navigation conditions near the upstream entrance to the proposed lock canal and flow conditions in the approach to the spillway, and develop modifications required to eliminate any undesirable conditions. The model is of the fixed-bed type constructed to an undistorted scale of 1:100. The model reproduces about 2-1/2 miles of the Tombigbee River between river miles 283 and 286, about 1-1/2 miles northeast of Gainesville, Alabama, adjacent overbank areas, gated spillway, upper reach of the lock approach canal, fills, and overflow sections.
(*f*) Completed.

(*g*) Satisfacory navigation can be developed at the entrance to the lock approach canal and in the waterway upstream of the canal. The development of basic plans required for satisfactory navigation for one- and two-way traffic has been completed.

314-09725-350-13

WALNUT CREEK CHANNEL IMPROVEMENT–CALIFORNIA

(*b*) Sacramento District.
(*c*) Glen Pickering.
(*e*) The hydraulic capacity of the existing Broadway Conduit at the confluence of Walnut, San Ramon, and Las Trampas Creeks, Walnut Creek, California, is to be determined. Should the conduit be inadequate to pass design flows, appropriate modifications to the structure will be investigated. As the capacity of the structure cannot be reliably calculated, a hydraulic model study will be employed.
(*f*) Tests completed.

314-09726-400-13

HYDRAULIC MODEL STUDIES OF SAN FRANCISCO BAY AND SACRAMENTO-SAN JOAQUIN DELTA, CALIFORNIA

(*b*) San Francisco District.
(*c*) Mr. Marshall A. Blank.
(*e*) The purpose of the model studies is threefold: (1) to support the San Francisco Bay and Sacramento-San Joaquin Delta Water Quality and Waste Disposal Investigation (this relates to model studies of interdistrict and interagency proposed plans that can influence water quality in the Bay and/or Delta), (2) to provide a means of evaluating other plans and operating procedures in the Bay-Delta Estuary, and (3) to provide a laboratory for research and development for studies and proposals of academic and regional interests. One plan is to prepare a velocity grid of the San Francisco Bay system which will indicate by arrows on a series of charts the surface current at two-hour intervals throughout the tidal cycle. This information will be of regional interest to the Coast Guard (oil spill planning), yachtsmen, and other local users of the San Francisco Bay Waters.
The method of evaluation consists of measurement and observation, including photographic methods, of tides, currents, salinity, sedimentation, and dispersion patterns under existing conditions of development and determination of changes in these items for various projects, proposals or concepts.
Base and Plan tests were conducted during the report period for various operating conditions for the J. F. Baldwin and Stockton ship channels project and for the proposed Peripheral Canal. Methods of operation and measurements were improved to achieve dependable repeatability of tests. Devices were added and improved to simulate both quantity and salinity of agricultural drainage from the islands in the Delta to the rivers and sloughs. The salinity results for both base and plan conditions have been put into a computer program which plots the input data and computes and plots the average of surface and bottom salinity. Model tests combining both the Peripheral Canal and the J. F. Baldwin and Stockton Channels projects have been completed. One objective was to determine the freshwater releases required to restore salinity to the base conditions.
(*h*) **Model Verification and Results of Sensitivity Tests,** *Tech. Memo. No. 1*, in preparation.

314-10741-310-00

IDENTIFYING AND MONITORING SELECTED FLOODPLAIN CHARACTERISTICS

(*c*) J. H. Shamburger, H. K. Woods.
(*e*) The objective of this study is to determine the utility of LANDSAT to monitor changes in selected floodplain characteristics: 1) Wetlands including extent and duration of flooding; 2) Present and potential land utilization; 3) Physical characteristics such as river channel changes, areas of erosion and deposition, and flood susceptible areas.
This investigation will utilize the spectral signatures of floodplain environments to determine pedological, vegetative, morphological, and hydrological characteristics that are pertinent to environment control of physical or cultural changes. The study will be conducted in a selected portion of the Mississippi River floodplain where extensive ground truth data and historical imagery are available. As a result of the spring 1973 and spring 1975 floods, considerable changes in the river regime have taken place. Pre-, during-, and postflood LANDSAT and aircraft imagery is available.

314-10742-320-00

EFFECTS OF WATER FLOW ON RIPRAP IN FLOOD CHANNELS

(*c*) J. L. Grace, Jr., N. R. Oswalt.
(*e*) To develop adequate criteria for design of stable riprap protective linings for flood channels. A large discharge capacity (500 cfs) channel research facility is scheduled for construction during FY 77 and 78 which will permit conduct of systematic tests and collection of appropriate data needed to develop adequate criteria for design of stable riprap protection in straight and curved reaches of flood channels. During the interim, FY 76 and 77, generalized data analyses of recent specific project model studies will be conducted to correlate the interrelations between geometric and hydraulic characteristics with initial displacement of various sizes, weights and gradations of riprap. Testing of riprap stability on channel side slopes will be conducted in existing model facilities. In addition, efforts will be continued to develop an adequate means of predicting the distribution of velocity and flow in natural and man-made flood channels. This is a prerequisite for applying either the critical shear, maximum permissible velocity or Froude number of flow design concept to determine the size and extent of riprap required in flood channels.

314-10743-330-00

RELATIONSHIP OF BENDS AND CHANNEL WIDTHS FOR PUSH TOWING

(*c*) L. J. Shows.
(*e*) To develop criteria which would establish a basis for reasonable design for navigation channel width in bends on inland waterways. With a known tow size and the maximum deflection angle (angle between the tow and a tangent to the curve at the stern of the tow) assumed by the tow in navigating a particular bend, the required channel width can be easily computed. However, the deflection angle is dependent on many factors, some of the most critical of these are: (1) Radius of curvature, (2) Degrees of curvature traveled by tow, (3) Tow draft, width, and length, (4) Speed of tow in relation to currents, (5) Direction and velocities of currents, (6) Direction of travel of tow (upstream or downstream), (7) Tow flanking or drifting around the bend, (8) Alignment and position of tow entering bend, (9) Relationship of navigable channel limits to the bank lines (particularly the concave bank). An undistorted semi-fixed bed hydraulic model reproducing typical river bends to a scale ratio of 1:120 and remote control model towboats will be used in model tests to establish the relationship between bend radii and tow deflection angles. The model will be operated with a constant flow condition in the bendways with different radii. The model towboat representing the different tow sizes will be operated through the model and the channel section wil be altered to provide a minimum channel which would be considered safe for a particular size tow.

314-10744-330-00

IMPROVED CRITERIA FOR LOCK DESIGN

(*c*) G. A. Pickering, J. H. Ables, Jr.
(*e*) To provide improved design criteria for the several types of lock filling and emptying systems. In the past, designs have been accomplished largely by empirical methods based on results of hydraulic model studies of specific structures. Comprehensive tests are being conducted on different types of filling and emptying systems to obtain data over a wide range of conditions. Analysis of tests and other available data will result in improved generalized design information.

314-10745-630-00

PUMP STATION INFLOW-DISCHARGE HYDRAULICS

(*c*) J. L. Grace, Jr., B. P. Fletcher.
(*e*) To determine the effect of upstream flow conditions, inflow introduction and sump arrangement on approach flows to the pumps. To develop the criteria needed to design sumps hydraulically that will not necessitate extensive post construction modifications to obtain satisfactory flow conditions and pump performance. During FY 75, field investigations of a number of completed structures were made to familiarize laboratory personnel with the types of structures being constructed, with the problems involved and with some of the solutions used. These investigations will also provide a basis for determining the design of the experimental facilities and the type of tests needed to meet the objectives.

Studies will be conducted in facilities used for specific project studies of pump station sumps. Upon completion of the specific project studies, the results and the facility will be used in an effort to develop generalized design guidance. The facilities will be used to conduct additional tests and analyses which were not required for the specific project studies.

Through studies conducted on the models using the various combinations of upstream conditions and applicable sump arrangements and variations thereof, the resultant effect on pump performance can be determined. When undesirable conditions are encountered and the cause ascertained, corrective modifications will be developed.

The results of the tests and data analyses will be used to develop practical design guidance which can be used by the engineer in designing the pumping station substructure. The criteria developed will be applicable to all but the more complicated and unique stations occasionally encountered. The guidance developed will be distributed intermittently by means of ETL's. Upon completion of the study, an Engineer's Manual will be prepared to furnish guidance to the field.

314-10746-350-00

GENERAL SPILLWAY TESTS

(*c*) J. L. Grace, Jr., N. R. Oswalt.
(*e*) To obtain additional basic knowledge and improved criteria for design of spillway crest shapes and stilling basin sidewalls based on dynamic loadings caused by water flow. Tests will be conducted to verify the design procedure recommended for low spillways in MP H-73-5, "Spillway Crest Design." Discharge coefficients, pressures, and pier and abutment effects will be investigated. Various approach depths and upstream slopes will be studied.

Direct and continuous measurement of the magnitude and frequency of dynamic loads on various sizes of monoliths composing a typical spillway stilling basin sidewall will be recorded on oscillograph paper and magnetic tape. The data will be analyzed to determine the magnitudes of loads corresponding to various frequencies. The Froude number of flow entering the stilling basin and the actual depths of tailwater relative to the theoretical depth required for a hydraulic jump will be used to correlate hydraulic flow conditions with the magnitude and frequency of the dynamic loads imposed on the separate sidewall monoliths. Various sizes and configurations of baffles and endsills will be put into the basin in order to determine their effect on the dynamic loadings.

Discharge characteristics and periodic surging of flow on tainter gates will be investigated and drawdown at abutments of high spillways will be studied to determine the effects on stilling basin performance and to develop appropriate design guidance.

314-10747-330-00

LOCK CULVERT VALVE VENTILATION

(*c*) G. A. Pickering, J. H. Ables, Jr.
(*e*) To obtain satisfactory air venting at lock culvert valves by means of floor contraction and expansion immediately upstream and downstream of the valve with resulting negative pressures as a means of venting and reducing cavitation potential in lieu of expensive lowering of the culverts to accomplish the same objective. Many tests have been conducted in efforts to raise the minimum pressure gradient immediately below a valve to eliminate cavitation tendencies, but no tests have been conducted toward lowering this gradient. The result of the proposed contraction and expansion of the floor may result in negative pressures on the roof of the culvert adequate to assure satisfactory venting at a cost of only a few tenths of a minute in filling time. Existing lock models of specific structures would be used for the study as they become available. Various degrees of contraction and expansion would be tested on these models to determine their effect on the pressure gradient immediately downstream from the valves. This information could offer an inexpensive method of reducing and/or eliminating cavitation at lock culvert valves as well as improving the quality of water released.

314-10748-700-00

INTEGRATED DENSITY PROBE AND DEPTH SOUNDING SYSTEM

(*c*) B. K. Melton, T. J. Pokrefke.
(*e*) To develop an integrated system consisting of a depth sounder and remote density sensor which together will indicate a deposition of sediment, both depth and density, that would interfere with navigation and require dredging. The approach to this study includes: (1) An overall review of the problem to include published literature, USAE District experience, and state-of-the-art from a hardware standpoint. (2) Field sampling and laboratory analysis to determine the exact characteristics of the low density "fluff" material and the point where it becomes a problem for navigation. (3) Development of equipment capable of indicating the point at which the low density material must be removed to prevent hindrance to navigation.

314-10749-410-00

EDUCTOR SYSTEMS FOR SANDTRAP BYPASSING

(*c*) E. C. McNair, Jr., W. B. Fenwick.
(*e*) To develop effective systems for bypassing sand at tidal inlets and other obstructions to littoral transport. The research is directed to the development of a system which could be portable or permanently fixed and operated by a remote, probably land-based pumping plant. Evaluation of the techniques that have been attempted or proposed, a survey of possible existing equipment that could be applied, and definition of the most effective possibilities have been completed. A series of laboratory tests to define basic system parameters has been completed and a second series of tests to measure system performance under a variety of pumping conditions has been initiated. Initial field tests on the Gulf of Mexico and Middle Atlantic Coast have been completed. A field test at a Pacific Coast site will be initiated in the fourth quarter FY 76, and a

field test on the Great Lakes in FY 77 is in planning stages. Both laboratory and field tests will be completed, recommended equipment and procedures will be determined, and a user manual oriented to field use will be prepared and published.

314-10750-750-00

DEVELOPMENT AND EVALUATION OF PHYSICALLY SCALED RESERVOIR/WATERSHED ECOSYSTEM MODELS

(*c*) Dr. R. L. Eley, Mr. D. L. Robey.
(*e*) To develop and evaluate the concepts, techniques, and facilities necessary to design and apply scaled models and other physical simulation techniques to reservoir/watershed ecosystems for the purpose of determining environmental impacts of reservoir operation and management strategies, including the management of environmental quality problems. To provide CE District offices with guidance on appropriate applications and techniques for using scaled reservoir/watershed ecosystem models for environmental impact prediction and the management of environmental quality problems.

314-10751-880-00

EVALUATION AND APPLICATION OF MATHEMATICAL RESERVOIR ECOSYSTEM MODELS

(*c*) Dr. R. L. Eley, Mr. D. L. Robey.
(*e*) To evaluate selected existing mathematical water quality and ecological models which appear to be applicable to CE reservoir environmental problems. To incorporate the more desirable existing mathematical modeling techniques into a mathematical reservoir ecosystem model suitable for application to field problems. To develop improved algorithms for water quality and biological processes to be used in mathematical ecosystem models. To test the applicability of these models to a variety of priority CE District environmental problems on a regional basis. To develop user-oriented guidance on the selection, application, and interpretation of water quality and ecological models as predictive tools in the form of Engineering Manuals, Technical Reports, and Miscellaneous Papers.

314-10752-860-00

RESERVOIR HYDRODYNAMICS (SIMULATION OF QUALITY IN WATER RESOURCES)

(*c*) J. L. Grace, Jr., D. G. Fontane.
(*e*) To investigate new and modified methods and techniques for simulating, predicting and regulating the hydrodynamics of reservoirs and physical water quality parameters. Results will be incorporated into existing mathematical and physical modeling techniques to provide the improved capability required to simulate, predict and control water quality in proposed and existing lakes.
Physical investigations of a generalized reservoir in conjunction with development of predictive mathematical techniques will be used to develop adequate means for describing the hydrodynamics and budgeting physical water quality parameters in reservoirs. The physical model will be capable of simulating the heat transfer at the air-water interface, the inflow temperatures, and the inflow and outflow hydrographs. The model operation and data collection will be computer controlled. One- and two-dimensional mathematical modeling techniques will be improved based on the results of the physical model.

314-10753-860-00

METHODS OF ENHANCING WATER QUALITY

(*c*) J. L. Grace, Jr., D. G. Fontane.
(*e*) To use physical models to investigate various techniques including destratification, reaeration and hypolimnion oxygenation for improving the quality of water in lakes and rivers. The destratification studies are being conducted in a 40-ft-long × 3-ft-wide × 2-ft-deep plastic flume. Initial testing consisted of a comparison of pumping water versus air to achieve various degrees of mixing of a two-layered stratification. The water pumping technique is being studied in detail to determine relationships between degree of mixing, initial stratification, efficiency, time, reservoir size, input power requirements and pumping configuration. Reaeration studies are being conducted to determine the factors which affect gas transfer in flow passing over and through hydraulic structures. A prototype spillway has been selected on which gas transfer measurements have been made. A model of the prototype has been constructed and model data are being collected. Various structural modifications are being made to the model to determine the respective effects on gas transfer characteristics. The same procedure will be followed for flow through an outlet works structure. These studies will provide guidance for designing hydraulic structures not only to pass desired rates of flow and dissipate energy, but also to degas or reaerate flows as desired. Practical guidelines for reaerating flow and destratifying lakes will be developed and published for field use.

314-10754-860-00

PREDICTION AND CONTROL OF WATER QUALITY

(*c*) D. G. Fontane, B. Loftis.
(*e*) To develop, document and distribute a one-dimensional mathematical model and users manual capable of simulating, budgeting and routing physical water quality characteristics through a reservoir. A one-dimensional simulation model, to be identified as "WESTEX," has been developed at WES and has been used to route temperature, dissolved oxygen and turbidity through lakes. Further model development areas can be identified now and the expanding technology will provide new descriptions of processes affecting water quality. These descriptions will be included in the WESTEX model and the model will be fully documented and the user's manual published.

314-10755-060-00

IMPROVED CRITERIA FOR DESIGN OF SELECTIVE WITHDRAWAL STRUCTURES

(*c*) M. S. Dortch, D. G. Fontane.
(*e*) To develop an improved understanding of the mechanics of density stratified flow and to develop improved criteria for design of selective withdrawal structures. Physical models will be used to evaluate blending of density-stratified flows in outlet works and to evaluate the selective withdrawal characteristics of various port configurations. The results of the physical models will be used to update the existing WES Generalized Selective Withdrawal Techniques and to develop design guidance for selective withdrawal systems.

314-10756-870-00

FIELD STUDIES ON WASTEWATER TREATMENT BY OVERLAND FLOW

(*c*) Dr. P. G. Hunt, Dr. R. L. Eley.
(*e*) To evaluate in natural conditions, treatments, and treatment combinations and theory that appeared promising in greenhouse modeling research. The research is to be conducted at Utica, Mississippi, on a 5-acre plot adjacent to the city's facultative lagoon. Eight plots in 15- × 150-ft dimensions (normal length) will be established at 2, 4, and 8 percent slopes. The initial cover crop will be Reed canary grass. Wastewater will be applied at rates varying from 0.33 acre-in in 18 hr to 1.0 acre-in in 6 hr. Volumes applied per week will vary from 1.5 to 3.0 acre-in. Wastewater will be collected at various locations down the slope and analyzed for N, P, and heavy metals as will grass and soil samples. These test combinations should verify earlier test results on overland flow models. They should provide the basis for direct design of small systems, less than 3 or 4 mgd, and the basic information for the design of large-scale demonstration systems for overland flow. Weather information and replicated plots will provide the basis for

sound modeling of the overland flow systems in the southeast. These data along with physiochemical and biological data can be analyzed to allow correlations to be established as well as provide the field test proof of overland flow theory.

314-10757-870-00

WATER, WASTE, AND WASTEWATER SYSTEM–ROLE OF LAGOONS IN SMALL-SCALE WASTE TREATMENT SYSTEMS

(*c*) A. J. Green, N. R. Francingues.
(*e*) To collect, develop, and disseminate implementable information on the design, operation, and costs of wastewater treatment lagoons as they apply to small-scale systems at Corps of Engineer facilities.
A review of current lagoon technology and on-going lagoon research will be made. Promising techniques and practices revealed by this review, which apply to Corps of Engineer areas of responsibility, will be recommended for possible implementation.
An in-depth survey will be made of Corps divisions and districts to assess the extent of lagoon use at recreation and other areas with particular emphasis on identification of problems and successes in existing lagoon treatment systems. Problem areas may indicate possible research areas, and markedly succesful operations will be examined for techniques implementable elsewhere.
Plans will be made to develop and conduct field studies where necessary to fill information gaps in the area of quantitative lagoons performance characteristics and to develop new design and operation methods for use in improving lagoon performance to meet Federal standards (PL 92-500), etc.
An underlying driving force inherent in this study is that lagoons are potentially one of the lowest cost (both capital and O&M) means of achieving satisfactory treatment of wastewater. Accordingly, the development of realistic cost data and money savings techniques will be accomplished concurrently with technical aspects.
A comprehensive document will be prepared which will provide operating and design guidance for new lagoon systems as well as the upgrading of existing ones. It will include cost and performance data usable to engineering as well as operations personnel and specifically applicable to Corps of Engineer facilities and activities.

314-10758-870-00

EVALUATION AND APPLICATION OF MATHEMATICAL WATERSHED/RIVERINE ECOSYSTEM MODELS

(*c*) Dr. R. L. Eley, Mr. D. L. Robey.
(*e*) To evaluate selected existing mathematical watershed/riverine ecosystem models. To modify and improve specific models for environmental impact prediction and water quality management. To develop user-oriented guidance on the selection, application, and interpretation of mathematical watershed/riverine ecological models as predictive tools.

314-10759-330-00

CHANNEL DIMENSIONS AND ALIGNMENT FOR SAFE AND EFFICIENT NAVIGATION

(*c*) G. A. Pickering, H. O. Turner.
(*e*) To determine the minimum dimensions of navigation channels compatible with the assurance of safe operating conditions. It is imperative that rational maintenance procedures be established in order that channel dimensions can be minimized while still maintaining safe navigation conditions.
There are several items that influence design and maintenance of navigation channels. Some of these are ship dimensions, ship power to weight ratio, rudder and propeller assemblies, type of traffic, ship speed, pilot ability and weather conditions. Curves will be developed to define channel dimensions in terms of these pertinent variables. The data will be published in a comprehensive research report. The research program will be carried out primarily as a physical model study utilizing free running model ships.

314-10760-350-00

PIPING AND RAINFALL EROSION IN DISPERSIVE CLAY EMBANKMENTS

(*c*) E. B. Perry.
(*e*) To study piping and rainfall erosion in dispersive clay embankments such as Grenada Dam, Mississippi.
Pinhole erosion tests, soil pore water chemistry, SCS dispersion tests, and Crumb tests will be conducted on both undisturbed and remolded soil samples from Grenada Dam to determine the susceptibility to dispersive clay erosion.

U.S. DEPARTMENT OF COMMERCE, NATIONAL BUREAU OF STANDARDS, INSTITUTE FOR BASIC STANDARDS, CRYOGENICS DIVISION, CRYOGENIC FLUID DYNAMICS SECTION, Boulder, Colo. 80302. D. B. Mann, Acting Section Chief.

315-07005-110-00

CRYOGENIC FLOWMETERING

(*b*) Joint NBS-Compressed Gas Association Program.
(*c*) Mr. J. A. Brennan, Mechanical Engineer.
(*d*) Experimental; applied research.
(*e*) Determine performance of flowmeters under controlled cryogenic conditions, investigate new flow measurement methods, provide transfer standard calibrations.
(*g*) The facility is presently operational and is being used to evaluate measurement devices such as turbine, momentum, vortex shedding, and orifice meters.
(*h*) **NBS-CGA Cryogenic Flow Measurement Program,** J. A. Brennan, R. W. Stokes, C. H. Kneebone, D. B. Mann, *ISA Transactions* **4**, 3, pp. 237-247, 1975.
Progress Report on Cryogenic Flowmetering at the National Bureau of Standards, J. A. Brennan, J. F. LaBrecque, C. H. Kneebone, *Instrumentation in the Cryogenic Industry* **1**, *Proc. 1st Biennial Symp. on Cryogenic Instrumentation, ISA*, Paper 621, Oct. 11-14, 1976.

U.S. DEPARTMENT OF COMMERCE, NATIONAL BUREAU OF STANDARDS, INSTITUTE FOR BASIC STANDARDS, MECHANICS DIVISION, FLUID MECHANICS SECTION, Washington, D. C. 20234. P. S. Klebanoff, Section Chief.

316-07243-060-20

MEASUREMENT OF LEE WAVE DRAG ON SPHERES

(*b*) Office of Naval Research, Dept. of the Navy.
(*c*) Mr. Karl Lofquist, Physicist.
(*d*) Experimental and theoretical; basic research.
(*e*) Measurement of difference in drag between sphere moving in linearly stratified salt water and in fresh water.
(*f*) Experiments completed. Report pending.

316-07824-410-11

SAND TRANSPORT BY WAVES

(*b*) Coastal Engineering Research Center.
(*c*) Mr. Karl Lofquist, Physicist.
(*d*) Experimental and theoretical; basic research.

(*e*) Investigation of the effect of seepage flows, caused by passage of waves over a permeable bed, on the sand transport in the offshore zone.
(*f*) Completed.
(*g*) A positive permeability effect was found, in that sand ripple profiles move in the onshore direction. The velocity of this motion was measured and is described in terms of wave and bed parameters.
(*h*) **An Effect of Permeability on Sand Transport By Waves,** K. E. Lofquist, *CERC Tech. Memo. TM-62*, Dec. 1975.

316-08652-700-00

WATER POLLUTION FLOW MEASUREMENTS

(*c*) G. Kulin, Hydraulic Engineer.
(*d*) Experimental; basic and applied.
(*e*) To develop liquid velocity measurement standards and provide flow measurement support to Government and industry. To evaluate and improve flow measuring instruments and procedures needed in water pollution control and devise means for transferring flow measurement capability from laboratories to field users. To bring on line a new high performance water tunnel to serve as a velocity standard and to do supporting development of tunnel instrumentation in a temporary gravity-flow tunnel. To investigate turbulence effects on bucket-type current meters. To evaluate the performance of rotating element current meters at velocities lower than those at which they are routinely calibrated and under conditions encountered in velocity-area traversing of small conduits for flowrate determination. To evaluate procedures for field calibration of measuring flumes, weirs and other devices by current meter traverses and by other methods, and to identify and quantify errors caused by improper installation of those instruments. To prepare publications aimed at transferring these results and related measurement capability to field users, particularly to industrial dischargers performing compliance monitoring to meet EPA discharge permit requirements. To improve communication among manufacturers, users, regulators and NBS by arranging conferences and working groups.
(*g*) Work was completed on Price and Pygmy water current meters, including investigations of their low-velocity performance, accuracy of individual vs. group ratings, and selected studies on effects of boundaries, velocity gradients and method of suspension (rod or cable). Experiments on the effects of geometry changes on a three-inch Parshall flume were completed and a paper was prepared which includes guidelines for estimating these effects for larger flumes. A numerical model was developed and experimentally verified for flow through a class of two-dimensional flumes. Efforts are now in progress to develop a numerical model for three-dimensional flume flow, specifically for the Parshall flume. An adjustable-slope open channel with a rectangular section three-feet wide by one and one-half feet deep was placed in service. A six-inch Parshall flume has been installed in it to examine effects of various upstream velocity distributions collaboratively with the numerical modeling effort. Construction of a high-performance water tunnel was continued on an outside contract.
(*h*) **A Guide to Methods and Standards for the Measurement of Water Flow,** G. Kulin, P. R. Compton, *NBS Spec. Publ. 421*, May 1975, GPO Cat. No. C13.10:421.
Discussion by G. Kulin of **Simplified Application of Palmer-Bowlus Flumes,** R. G. Ludwig, J. D. Parkhurst, *J. Water Poll. Cont. Fed.* **48,** 1, pp. 200-201, Jan. 1976.
Discussion by G. Kulin of **Sediment Transport in Smooth Fixed Bed Channels,** P. Novak, C. Nalluri, *Proc. ASCE* **102,** HY10, pp. 1601-1602, Oct. 1976.
Effect on Parshall Flumes of Slope and Geometry Changes, G. Kulin, R. W. Davis, submitted to *ASCE*.
Numerical Modeling of Two-Dimensional Flumes, R. W. Davis, *Proc. NBS Flow Measurement Symp., NBS SP 484*, Feb. 1977.
Some Error Sources in Price and Pygmy Current Meter Traverses, G. Kulin, *Proc. NBS Flow Measurement Symp., NBS SP 484*, Feb. 1977.

316-09731-020-52

STRUCTURE OF TURBULENCE

(*c*) P. S. Klebanoff, NBS, and F. N. Frenkiel, DTNSRDC, Carderock, Md.
(*d*) Experimental, and analytical, basic research.
(*e*) To develop and devise measurement techniques incorporating analog and digital methods for the measurement of the statistical properties of turbulence, and to provide significantly new data which will extend our knowledge of turbulent processes. The microstructure of turbulence will be investigated using hot-wire instrumentation and high-speed computing methods. Analog recordings of turbulent data are made on multi-channel magnetic tape for a turbulent field established in the NBS wind tunnel. The analog data is digitized and analyzed at NSRDC. Both isotropic and anisotropic turbulent fields will be studied with special emphasis being given to the flow downstream of a turbulence producing grid and in a turbulent boundary layer. However, apart from the forementioned investigation, which is carried out in collaboration with NSRDC, there is, in addition, an investigation of the relatively unexplored turbulence structure of low Reynolds number turbulent boundary layers which will be studied using laser velocimetry and hot-wire anemometry.
(*g*) Higher-order moments of the gradient of the longitudinal velocity fluctuation were measured at higher free stream turbulence levels. The higher free stream turbulence was created by fluttering aluminum tags attached to a 1-inch mesh grid. The results obtained at the higher free stream turbulence were in good agreement with those obtained at lower turbulence levels. Measurements of the higher-order moments of the gradient of the longitudinal velocity fluctuation in a turbulent field downstream of a grid in the 3-ft water tunnel at DTNSRDC were completed. These also showed the same behavior of the higher-order moments.
Further measurements were made using a probe to measure simultaneously the three components of turbulent velocity fluctuations. Higher-order moments of transverse velocity fluctuations have been obtained and are currently being evaluated. Measurements of distributions in the boundary layer of mean velocity have been made down to a free-stream speed of 9 ft per second. It is planned to investigate to how low a Reynolds number a characteristic turbulent boundary layer can be maintained. It is also planned to make measurements of turbulence quantities in the low Reynolds number turbulent bounday layer.
(*h*) **On The Lognormality of The Small-Scale Structure of Turbulence,** F. N. Frenkiel, P. S. Klebanoff, *Boundary Layer Meteorol.* **8,** 2, p. 173, 1975.

316-09732-250-50

DRAG REDUCTION

(*b*) National Aeronautics and Space Administration, Langley Research Center.
(*c*) Dr. J. M. McMichael.
(*d*) Experimental and analytical, basic and applied research.
(*e*) Determine the feasibility of obtaining drag reduction by the use of compliant boundaries. The investigation will be conducted on a specially designed flat plate in the 5-ft x 7-ft test section of the NBS dual-test section wind tunnel. Several types of compliant surfaces will be examined. Parameters to be varied include the lateral and longitudinal tensions in the surface, the thickness of the substrate, boundary layer thickness, and free-stream velocity. Provisions will be made for obtaining overall surface drag by a direct method. In cases where significant drag reduction is obtained, the affected structure of the boundary layer will be investigated in detail.
(*g*) The study of the rigid reference surface in air has been completed. This study consisted of overall skin friction measurements over a range of air speeds, detailed mean velocity and turbulence intensity distributions within the boundary layer, and a detailed evaluation of the "gap" effect. The latter arises from having a floating panel

mounted within a much larger plate. The forementioned measurements had to be made to demonstrate not only internal consistency but the accuracy of the methods adapted before proceeding to a study of the compliant surface. The compliant surface is currently being prepared for installation in the wind tunnel.

Construction drawings have been submitted to the NBS machine shop for the flat plate to be used in the drag reduction study to be conducted in the NBS water tunnel. Different methods for measuring the overall skin friction drag and for applying tension to the compliant membranes for the investigation in water had to be devised from those used in the wind tunnel investigation, and these have been designed.

The study of the compliant surface in air will be initiated. Measurements of overall skin friction drag will be made over a range of air speeds for varying lateral and longitudinal tensions of the compliant membrane. Other parameters to be varied are the nature of the substrate and the boundary layer thickness. The vibrational modes of the compliant surface will also be monitored. In addition to overall skin friction measurements, measurements of appropriate mean flow and turbulence properties will be made.

Progress in regard to the drag reduction investigation in water depends on delivery of the NBS water tunnel and how soon it can be made operational. In the interim it is planned to have the NBS machine shop proceed with the construction of the flat plate as rapidly as possible to avoid any untoward delay. Once the plate is installed in the water tunnel, the flexure balance that has been designed for the measurement of overall skin friction drag will be evaluated, and the behavior of the rigid reference will be investigated.

316-10779-410-11

OSCILLATORY WATER TUNNEL

(*b*) Coastal Engineering Research Center.
(*c*) K. E. Lofquist, Physicist.
(*d*) Experimental.
(*e*) Description of a positive displacement oscillatory water tunnel.
(*f*) Completed.
(*g*) See (h).
(*h*) **A Positive Displacement Oscillatory Water Tunnel,** K. E. Lofquist, *CERC Misc. Rept. 77-1*, Feb. 1977.

316-10780-410-11

OBSERVATIONS OF OSCILLATORY SAND RIPPLES

(*b*) Coastal Engineering Research Center.
(*b*) K. E. Lofquist, Physicist.
(*d*) Experimental.
(*e*) Observation of the initiation, growth and final stable forms of oscillatory sand ripples in relation to given wave and bed parameters.
(*f*) Completed.
(*g*) Previous results that the size of two-dimensional equilibrium ripples is proportional to the amplitude of the water flow were confirmed and extended. New results were obtained regarding the development and growth of ripples and the variability of their final forms.
(*h*) **Observations of Oscillatory Sand Ripples in a Water Tunnel,** K. E. Lofquist, *CERC Tech. Memo.* (in preparation 1977).

316-10796-700-00

FLUID MECHANICAL MEASUREMENTS

(*c*) P. S. Klebanoff.
(*d*) Basic research; theoretical and experimental.
(*e*) To improve the technical base for fluid mechanical measurements, and provide the technical data and the extended measurement services required by the nation's technology.

Flow processes involving the measurement of air and water velocity play important roles in such areas of national concern as health and safety, energy and the environment. Public awareness has focused on problems associated with the discharge of pollutants into the atmosphere, and the nation's water resources, the occurrence of water shortages, and the air flow to be maintained in connection with industrial ventilation. As a result more stringent requirements have developed for the accuracy of air and water velocity measurements, and improved measurement methods for steady and turbulent flows. All surface water flows in nature and most wastewater flows occur as open-channel flows, yet many characteristics of these flows need to be better defined. Improved water flow measurements are therefore needed not only for water measurement and control, but also to further the understanding of the flow process itself. Regulations concerned with health and safety have also imposed requirements for extending the range and precision of air velocity measurements. Concomitantly, all flows important to the environment, and many aspects of the nation's technology are turbulent, imposing a need for a competence in turbulence measurement, and an understanding of the effect of turbulence on fluid mechanical instrumentation.

By theoretical analysis and experimental evaluation achieve an improved understanding of the performance of aerodynamic and hydraulic instrumentation. This incorporates developing methods for describing the properties of free-surface flows, with emphasis on partly full circular channels, developing capabilities for improved low velocity measurements in air and water, investigating the effect of turbulence on the performance of anemometers and water current meters, and by analog and high speed digital computing techniques improve instrumentation and methods for turbulence measurements.

(*g*) Progress was hampered by the fiscal situation and although work on some aspects had to be delayed, substantive progress was made in a number of areas. A survey of available information on flow in part-full circular pipes was completed. The publication, "Hydraulic Research in the United States and Canada, 1976," was prepared and edited. A modification to the NBS laser velocimeter was completed which decreased the standard deviation of the individual particle velocities in the averaging process by a factor of five.

A calibration capability for the dynamic response of anemometers has been established. The experimental phase of an investigation concerned with the nonlinear spectral characteristics of a helicoid anemometer has been completed. The first draft of a report describing the NBS Unsteady Flow Facility has also been completed.

(*h*) **The Dynamic Response of Helicoid Anemometers,** J. M. McMichael, P. S. Klebanoff, *NBSIR 75-772*, Nov. 1975.

317-10797-700-34

ANEMOMETER PERFORMANCE AT LOW VELOCITIES

(*b*) Bureau of Mines.
(*c*) L. P. Purtell.
(*d*) Applied research.
(*e*) Evaluate the behavior of anemometers considered for mine use at low-flow velocities. The Federal Coal Mine, Health and Safety Act of 1969 (Public Law 91-973, December 30, 1969) authorizes the Secretary of the Interior to establish flow velocity requirements for mine ventilation, and to designate appropriate instrumentation for such measurements. The Mine Enforcement and Safety Administration (MESA) of the Department of Interior, established in 1972, has the responsibility for establishing and enforcing the regulatory standards for appropriate mine ventilation procedures. A major difficulty, in the past, in establishing flow velocity standards was the lack of a capability to evaluate the performance and applicability of ex-

isting and new instrumentation for the measurement of very low air velocities. The development of the NBS Low-Velocity Airflow Facility has provided this capability and enabled NBS to respond to the need of the Bureau of Mines and MESA.

Using the low-velocity facility, and the recently developed laser velocimeter, an experimental evaluation will be conducted of the behavior of standard and prototype air speed measuring instruments as a function of previously characterized low-velocity air flows. Particular emphasis will be given to the speed range 10 ft/min to 600 ft/min. The instruments will be supplied by the Bureau of Mines. Also to meet the needs of the Department of the Air Force, the feasibility of designing a scaled-down version of the NBS Low-Velocity Airflow Facility will be investigated.

(*g*) Six instruments that may serve as possible transfer standards have been evaluated. These instruments consisted of four anemometers of the vane type, a vortex shedding anemometer, and a vane deflection anemometer. A draft of a typical instrument evaluation report has been prepared and is presently being iterated with the Bureau of Mines as to the final format. It is planned to continue with the evaluation of other types of instrumentation for mine use.

316-10798-010-27

BOUNDARY LAYER CONTROL

(*b*) Arnold Engineering Development Center.
(*c*) P. S. Klebanoff.
(*d*) Experimental.
(*e*) To improve the performance of compressible flow wind tunnels as laboratory instruments for obtaining reliable test and design data.

The transition from laminar to turbulent flow in boundary layers is one of the important problems in fluid mechanics, and an important design parameter for aeronautical and aerospace vehicles. The present state of affairs is such that no reliable design data on transition can be obtained from model tests in compressible flow wind tunnels. This has raised significant questions as to the adequacy of compressible flow tunnels for such measurements. With the many millions of dollars invested in such facilities such a limitation is naturally of great concern, but more important is the lack of adequate design data. Apart from the fact that transition test results in the laboratory cannot be extrapolated to flight conditions, the present situation is such as to prevent the proper study and development of laminar flow control methods for reducing drag and heating on vehicle components, and inhibits fundamental research on boundary layer stability and transition. A number of major technical meetings, both national and international, have been held on the subject, and a study group has been established with the sponsorship of the Air Force. The result has been that improving the performance of ground based facilities has become a high priority objective.

Two aspects of the problem are being investigated. One which has been under investigation for a number of years is to determine the feasibility of laminarizing boundary layers in the test sections of compressible flow tunnels by using suction. This aspect utilizes the NBS Mach 2, 3-inch by 4-inch tunnel. The other is the effectiveness of boundary layer "trips" at transonic speeds. Involved herein is a study of modifications to the Mach 2 tunnel in order to operate in the transonic regime, and a fundamental study, at incompressible flow speeds, of the behavior of three-dimensional roughness elements in inducing transition which will be conducted in the NBS unsteady wind tunnel.

(*g*) Good progress has been made in increasing the region over which laminarization of the wall boundary layers in the test section of a supersonic tunnel can be obtained. Using the adjustable-tapered-rodded sidewall laminar boundary layer flow has been achieved over practically the entire sidewall at a stagnation pressure of one atmosphere, corresponding to a Reynolds number per inch of 0.3×10^6. At stagnation pressures above one atmosphere the degree of laminarization begins to deteriorate. Apparently the thinner boundary layer at the higher stagnation pressure becomes more sensitive to surface irregularities. Design and construction drawings for an adjustable-rodded nozzle block that minimizes these irregularities have been completed and have been submitted to the NBS machine shop. Construction should be completed shortly. The nozzle block is critical to the design of supersonic tunnels in that its shape characterizes the quality of the flow and the Mach number. The NBS design of the nozzle block, apart from the fact that it has been designed to minimize the surface irregularities referred to above, represents a new departure from traditional nozzle block design. In anticipation of the need to determine the effectiveness of boundary layer laminarization in reducing the level of disturbances in test sections, as well as to have sufficient background data for assessing the performance of the newly designed rodded-nozzle block, detailed distributions of the disturbance levels in the test section were made with turbulent boundary layers on both sidewalls and blocks. These measurements reveal several new features characterizing these disturbances and raise interesting questions as to their origin.

In regard to that aspect of the program concerned with boundary layer "trips," a 4-foot by 12-foot plate, with a 5 micro-inch finish, has been obtained, and a 5-degree wedge leading edge has been machined. The component parts for traversing downstream along the plate have been received, and construction drawings for a traverser to traverse across the boundary layer as well as in the spanwise direction have been completed and submitted to the NBS machine shops. A system for mounting the plate in the wind tunnel has been designed. The necessary hardware has been ordered and shop drawings are now being prepared. The design of the false wall for adjusting the pressure gradient along the plate has been initiated.

It is planned to continue with the program concerned with the laminarization of the wall boundary layers in the test section of supersonic tunnels by evaluating the performance of the newly designed rodded-nozzle block, and concomitantly to investigate the effect of wall laminarization on the level of disturbances in the test section.

In connection with that aspect concerned with the study of roughness elements on boundary layer "trips" it is planned to install the plate in the unsteady wind tunnel, and complete adjustment of the pressure gradient. The traversers will also be installed in the tunnel, and it is expected that measurements of the transition position, as well as the nature of the mean flow, induced by three-dimensional roughness elements will be carried out.

316-10799-010-18

BOUNDARY LAYER TRANSITION

(*b*) ARPA (via ONR).
(*c*) P. S. Klebanoff.
(*d*) Basic, experimental.
(*e*) To investigate the interrelationship between the fundamentals of boundary layer stability and such environmental factors as free-stream turbulence and surface cooling.

The state of the flow in boundary layers, i.e., whether laminar or turbulent, is a phenomenon of great practical importance, and an understanding of the fundamental processes that govern the transition from one state to the other can have a profound influence on many important technological problems. The particular technological thrust of this investigation is the impact an improved understanding of such processes can have on the design of air and water vehicles. The problem has long been in the forefront of the fluid mechanics discipline and has not only been the theme of numerous technical meetings but has also led to the establishment of a number of advisory committees on the subject. The technological importance of the problem has led the Department of Defense to mount a major governmental and industrial effort, and it is essential to progress that an improved technical base be established.

The investigation will be carried out in the NBS Dual-Test Section Wind Tunnel. The effect of free-stream turbulence on the transition Reynolds numbers will be studied using an axisymmetric body supplied by NAVSHIPS. Square-mesh grids will be used to generate the free-stream turbulence. The same body will be instrumented and adapted for investigating the effect of surface cooling on transition Reynolds number. Hot-wire anemometry will be used to quantify the free-stream turbulence and the state of the boundary layer. Longer range aspects include the interaction between free-stream turbulence, the laminar boundary layer, and the instability process.

(*g*) Much of the progress was concerned with making the necessary preparations for the investigation. These preparations for the most part consisted of the design and construction of square-mesh grids of varying sizes for generating free-stream turbulence, and the design and installation of an appropriate cooling system for the axisymmetric body using chilled water as the cooling agent. A challenging problem that had to be surmounted was the accurate positioning of thirty thermocouples on the interior surface of the body for the monitoring of surface temperature and surface temperature gradients. Measurements of the effect of free-stream turbulence and scale on the position of transition on the body in the presence of a favorable pressure gradient have been carried out in the 5-foot by 7-foot section of the dual-test section wind tunnel at wind speeds up to 130 feet per second. In order to extend the range of wind speed, the investigation has been transferred to the 4-foot by 5-foot test section. A mount for installing the body, and appropriate traversing equipment for the 4-foot by 5-foot test section were designed and constructed. Further measurements of the effect of free-stream turbulence and scale are currently being conducted.

It is planned to complete measurements of the effect of free-stream turbulence and scale on transition position. It is then planned to proceed with the effect of surface cooling on transition in a systematic and controlled manner for varying surface temperature differences from the ambient in the presence of favorable and unfavorable pressure gradients, and for free-stream turbulence of varying intensity and scale.

U.S. DEPARTMENT OF COMMERCE, NATIONAL BUREAU OF STANDARDS, INSTITUTE FOR BASIC STANDARDS, MECHANICS DIVISION, FLUID METERS SECTION, Washington, D. C. 20234. Dr. George E. Mattingly, Section Chief.

317-07242-700-22

AUTOMATED FLOW SYSTEMS

(*b*) Naval Air Systems Command.
(*c*) Dr. David W. Baker, Mechanical Engineer.
(*d*) Experimental; development.
(*e*) During the adjustment and calibration of gas turbine fuel controls, an operator manually sets input test parameters which remain stationary during a short time interval when test output data are manually recorded. Adjustments are made on the fuel control under test to bring performance within specified limits. In this program, methods and equipment for automatic testing and calibration of aircraft fuel controls were investigated. A prototype system was developed in which a minicomputer and digital-oriented control and readout equipment was used to automate a manually controlled test stand installed at NBS.
(*f*) Terminal efforts subcontracted to other agencies; NBS involvement completed.
(*g*) A software system was designed for operation of the prototype test system. This system was designed for simultaneous operation of up to five test stands. Development efforts were terminated at the completion of the design. In another phase of the program, computer programmed diagnostic aids for the fuel control adjustment process were developed. These programs were based on adjustment procedures devised by Bendix Corporation. A pilot run using several unadjusted fuel controls together with the diagnostics, indicates the adjustment process can be simplified by requiring fewer operator passes and effectively save operator time and effort. These diagnostic programs are being implemented into a Navy production facility.
(*h*) **A Prototype Automated Test System for J52 Engine Fuel Controls, Part 1. Hardware Systems Summary,** D. W. Baker, A. L. Koenig, V. Brame, Jr., National Bureau of Standards, *NBSIR 76-1071*, Apr. 1976.
ACJET, Accessory Calibration for Jet Engine Tuneups 1-10, W. C. Haight, H. W. Hawes, National Bureau of Standards, *Final Progress Report.*
A Software System for Calibration Diagnostics of Bendix Model CJ-N1 and CJ-G8 Fuel Controls 1-6, W. C. Haight, National Bureau of Standards, *Final Progress Report.*
An Automated Tune Up, Calibration of Jet Engine Fuel Controls, W. C. Haight, H. W. Hawes, *ASSC 74 Symp. Record, Automatic Support Systems, Symp. for Advanced Maintainability*, IEEE, Oct. 30-Nov. 1, 1974.

317-10789-750-00

MATHEMATICAL MODELING FOR DYNAMIC VOLUME MEASUREMENTS

(*c*) Dr. R. W. Davis.
(*d*) Theoretical.
(*e*) The objective of this project is to improve dynamic volume measurement capabilities by providing a basic understanding of the performance of closed-conduit measuring devices. The most important immediate objectives are to determine the effects of swirling flow on various types of measuring devices and to design an optimum upstream flow conditioner to improve the devices' reliability.

The current almost complete lack of knowledge concerning the internal workings of dynamic volume measuring devices is causing severe measurement uncertainty problems in American industry. Flow meter manufacturers and oil and gas pipeline users are among those who are concerned about this and who will benefit from this study. The NBS goal of dynamic volume measurement assurance will be aided by this project. Improvements in measurement accuracy related to fluid volume transfer will lead to more equitable usage and pricing in such areas of national concern as energy (e.g., natural gas prices).

Our approach here is to use mathematical modeling (in conjunction with carefully planned validation experiments conducted under (317-10793) in order to completely analyze the flowfields inside closed-conduit dynamic volume measuring devices operating under realistic conditions. Effects of changes in the operating environment of these devices (particularly the poorly understood target meter) will be assessed, with specific attention given to swirl effects. An attempt will be made to design an axially symmetric upstream flow conditioner which will minimize the effects of environmental changes on the measuring device. We currently have several computer codes with proven reliability available. These will be used and modified as required. New codes will be added as necessary.
(*g*) Using support from a related project, a turbulence modeling code (TEACH) developed at Imperial College, London, England, was obtained, modified and validated. This code was used to simulate turbulent flows through orifice meters operating under realistic conditions.

Initially, we plan to add a swirl subroutine to the TEACH code. Once this has been validated, we intend to perform a study of target meters both with and without swirl using the modified TEACH code. In addition, we will also study the effects of swirl on orifice plates. We will then make a study of flow conditioners in an attempt to find an optimum configuration for axially symmetric flow. Such a flow conditioner will markedly increase the reliability of dynamic volume measurements.

(*h*) **Numerical Modeling of Turbulent Flow Through Thin Orifice Plates**, R. W. Davis, *Proc. NBS 1977 Flow Measurement Symposium: Errors in Open Channel and Closed Conduit Flow Measurement: Their Sources, Assessment, and Resolution*, *NBS SP 484* (2 vols.), issued Oct. 1977.

317-10790-700-27

EXPERIMENTAL VALIDATION FOR MODELING A UVT

(*b*) U.S. Air Force, Wright-Patterson.
(*c*) Dr. G. E. Mattingly.
(*d*) Applied, theoretical.
(*e*) Design, construct, and perform an experiment to produce the required data to validate a mathematical model of a particular Universal Venturi Tube (UVT) in conjunction with conventional calibration data. The essential feature of the validation is to document any flow characteristics in the meter which would improve the performance of critical density and temperature instrumentation located downstream of the UVT.
The UVT meter will be one of four such meters used to measure flow in the USAF's new Compressor Research Facility being built at the Wright Patterson Air Force Base. The planned experiment will establish traceability to NBS for the flow measurement made at this facility.
An extensive calibration will be done for a scaled model of the particular meter. In addition, for three flows spanning the range of the meter, detailed velocity profile and pressure distribution measurements will be made and compared to results obtained by mathematically modeling this flow field.
(*g*) A scaled model of the particular meter has been ordered from the manufacturer of the full scale meters. Auxiliary equipment needed for the velocity and pressure measurements has been selected and ordered.

317-10791-700-00

INTERLABORATORY FLOW METER TEST

(*c*) Dr. G. E. Mattingly.
(*d*) Applied; experimental.
(*e*) As a preliminary step in establishing Flow Measurement Assurance Programs (MAPs), an interlaboratory flow meter test program has been conducted using small, momentum-type meters in water flows. Five laboratories, including NBS, voluntarily participated in setting up a test procedure which was designed to quantify interlaboratory agreement, or indicate the nature of variability that may exist among laboratories.
(*g*) Several rounds of tests have been conducted with the results appropriately reported to the participants. Anonymity of participants, testing details, and the results have been preserved as per the agreement desired by the participants until unanimous agreement is reached for making these items known. Limited expansion of the initial group of participants has incorporated one additional American laboratory and one foreign national laboratory.
(*h*) By agreement with participants, the report on the test and the results shall be limited to distribution only among the participants.

317-10792-700-00

AUTOMOTIVE EXHAUST FLOWMETER

(*c*) Dr. B. Robertson.
(*d*) Applied; theoretical.
(*e*) Develop and evaluate an essentially nonintrusive flowmeter for use along with existing real-time pollutant concentration detectors for measuring pollutant emissions from automobile tailpipes in real time. The flowmeter will be used on automobile production lines and in local testing stations to verify compliance with EPA regulations. It will also be used for engine testing. At present there is no flowmeter that can measure exhaust gas flow. The flowmeter uses a new long wavelength acoustic principle which requires a loudspeaker and two microphones just inside a pipe. Electronic circuitry is used to produce the appropriate frequencies at the loudspeaker and to process the microphone signals to obtain an output proportional to the volume flow rate of the exhaust.
(*g*) A preliminary version of the flowmeter was constructed and tested. The results suggested modifications which have been incorporated in a new design. Preliminary evaluation of the new technique indicates that it will be successful. Six and one-half of the seven printed circuit boards required for a prototype flowmeter have been completed, wired together, and tested.
(*h*) **Effect of Arbitrary Temperature and Flow Profiles on the Speed of Sound in a Pipe**, *J. Acoust. Soc. Am.*, Oct. 1977.
Synchronous Marker for Measuring Phase in the Presence of Noise, B. Róbertson, J. E. Potzick, *Rev. Sci. Instrum.* **48**, pp. 1290-1294, 1977.

317-10793-750-00

VALIDATION OF MATH MODEL OF DYNAMIC VOLUME

(*c*) Dr. B. Robertson.
(*d*) Applied; theoretical.
(*e*) Measure the velocity profile and turbulence levels of water flowing through various flowmeters and pipeline elements for validating the predictions of the mathematical model (see 317-10789). The results will be useful in designing new flowmeters and pipeline elements and in improving existing ones in order to obtain more accurate volume and flow measurements under adverse conditions.
Velocity profiles will be measured in a 5 cm orifice meter using the flow visualization method. This involves photographing hydrogen bubbles released in isolated bursts from a wire across the flow. The bubbles are electrochemically generated by applying 600 volt pulses to the wire. Future plans include other flowmeters and other pipeline elements and also turbulence measurements using a dual laser-Doppler velocimeter and a dual-channel signal processor. A positioning mechanism for our present one-channel LDV will be developed when funded.
(*g*) A new two-probe laser-Doppler velocimeter system has been designed that will be able to measure the cross correlation of the turbulent velocities in two independently movable 1 $mm^2 \times 4$ mm volumes. The LDV has been used to measure the velocity of automobile exhaust in support of project 317-10792. Preliminary evaluation of the feasibility of using that project's long wave length acoustic flowmeter in liquid flow has been completed.

317-10794-700-00

BULK MEASUREMENT OF NUCLEAR FUEL

(*c*) Dr. J. A. Simpson.
(*d*) Experimental, applied.
(*e*) Develop and disseminate measurement methodology for bulk measurements in nuclear fuel plants, validate measurement procedures for in-plant flow meters and evaluate the usefulness of reference standards to enhance the safeguard system.
Acountability of special nuclear materials, often called Safeguards, has attracted the attention of all levels of Government. It impacts on proliferation, possible terrorism and on the form of the future world-wide nuclear industry. It appears that energy demands of the future will require the completion of the fuel cycle and the resultant increase in production of special, i.e., weapon quality, nuclear material. The measurement of bulk quantities is central to any system of physical accountability.

Existing measurement technology will be adapted and combined with well-established Measurement Assurance techniques to validate the measurement systems *in situ* as they are realized in industry. Selected commercial components will be evaluated and knowledge of their characteristics combined with appropriate measurement methodology to enhance measurement methods as used in the field.

317-10795-700-00

SAFEGUARD: BULK MEASUREMENT METHODOLOGY

(*c*) Dr. J. A. Simpson.
(*d*) Experimental, applied.
(*e*) A well-characterized measurement methodology for bulk measurements, adequate for the control of special nuclear materials, will be developed.
Accountability of special nuclear materials, often called Safeguards, has attracted the attention of all levels of Government. It impacts on proliferation, possible terrorism and on the form of the future world-wide nuclear industry. It appears that energy demands of the future will require the completion of the fuel cycle and the resultant increase in production of special, i.e., weapon quality, nuclear material. The measurement of bulk quantities is central to any system of physical accountability.
Current bulk measurement methods, based on over-simplified concepts and equipment designed according to NBS HB44, has been time consuming and only marginally adequate. The approach is to assemble selected commercially available components into systems which optimize the performance of the components, thereby improving bulk measurement capabilities. The activities include (1) density and temperature corrections for fluid volume determination via simulated process tanks, (2) dynamic volume measurements, and (3) mobile meter testing facility.
(*g*) Planning and early design stages were completed for special purpose equipment that will be acquired to conduct experiments.

U.S. DEPARTMENT OF COMMERCE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, GEOPHYSICAL FLUID DYNAMICS LABORATORY, P.O. Box 308, Princeton University, Princeton, N. J. 08540. Dr. Joseph Smagorinsky, Director.

318-08449-450-00

GEOPHYSICAL FLUID DYNAMICS

(*d*) Basic research.
(*e*) Work is directed toward improving understanding of the physical and dynamical processes responsible for structure and variability of the atmosphere and oceans on a wide range of time and space scales. Numerical models are developed and simulation experiments are run on very large computers.
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U.S. DEPARTMENT OF COMMERCE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, GREAT LAKES ENVIRONMENTAL RESEARCH LABORATORY, 2300 Washtenaw Avenue, Ann Arbor, Mich. 48103. Dr. Eugene J. Aubert, Director.

319-10668-440-00

WATER MOVEMENTS AND TEMPERATURE

(*c*) Dr. D. B. Rao.
(*d*) Experimental and theoretical; basic and applied research.
(*e*) Develop improved climatological information on the distribution and variability of currents and temperatures and to study their dependence on meteorological and hydrological forces.
Develop and test improved numerical hydrodynamic models that can simulate and predict the temperature and current distributions in the Lakes.
Develop and test improved models to simulate and predict the transport and diffusion of pollutants and to participate in coupling these models to aquatic ecology and water quality models. A hierarchy of such numerical models of different complexities will be developed and tested for use as tools in water resources planning.
Improve the understanding of physical processes occurring in the lake by analyzing data and the results from the numerical models.
(*h*) **Saginaw Bay Water Circulation,** L. J. Danek, J. H. Saylor, *NOAA Tech. Rept. ERL 359-GLERL 6*, 1975.
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319-10669-440-00

SURFACE WAVES AND WATER LEVEL FLUCTUATIONS

(*c*) Dr. D. B. Rao.
(*d*) Experimental and theoretical; basic and applied research.
(*e*) Improve climatological information on the distribution and variability of surface waves, wind set-ups, surges, and seiches.
Develop improved theoretical and empirical models for the above phenomena for prediction purposes.
Develop models for the atmospheric boundary layer above the Lakes to provide the necessary input into the above prediction models.
Improve understanding of the physical processes involved so that numerical models can be improved.
(*h*) **An Evaluation of Parameters for the Theoretical Distribution of Periods and Amplitudes of Sea Waves,** P. C. Liu, *J. of Geophys. Res.* **81**, pp. 3161-3162, 1976.
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319-10670-810-00

HYDROLOGIC PROPERTIES

(*c*) Dr. F. H. Quinn.
(*d*) Experimental and theoretical; applied research.
(*e*) Develop a hydrologic data base of sufficient quality for both scientific and water resource studies of the Great Lakes. Parameters to be included are precipitation, runoff, ground water, evaporation, connecting channel flows, changes in lake storage, and beginning-of-month lake levels.
Develop improved numerical models to predict and simulate the water levels and flows through the Great Lakes system. Models to be developed include hydrologic response models of the entire system, hydraulic transient models for the connecting channels, water supply prediction models, and watershed hydrologic models.
Develop improved understanding of the hydrologic processes of the Great Lakes Basin as they relate to objective (2) above.
Provide a Great Lakes advisory service on water supply parameters, water levels, and flows.
(*h*) **Estimating Energy Budget Components to Determine Lake Huron Evaporation,** S. J. Bolsenga, *Water Resour. Res.* **11**, pp. 661-666, 1975.
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Annual and Seasonal Flow Variations Through the Straits of Mackinac, F. H. Quinn, *Water Resources Research* **13**, 1, Feb. 1977.

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U.S. DEPARTMENT OF COMMERCE, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, NATIONAL WEATHER SERVICE, Silver Spring, Md. 20910. Dr. Robert A. Clark, Associate Director of National Weather Service (Hydrology).

321-10671-300-00

RIVER MECHANICS RESEARCH ON UNSTEADY FLOWS

(*c*) Dr. Danny L. Fread, Research Hydrologist, Hydrologic Research Laboratory.
(*d*) Theoretical and field; applied research.
(*e*) Investigations are conducted to develop improved operational forecast mathematical models of one-dimensional unsteady flow in rivers, reservoirs, and estuaries. The models' computational efficiency, numerical accuracy, simulation accuracy, calibration effort, and data input requirements are investigated. Also, the modeling problems associated with meandering rivers with wide flood plains, stream-aquifer interactions, hurricane storm surges advancing upstream, dendritic system of rivers, dam-break flood waves, sediment transport effects on flow in sand-bed rivers are investigated.
(*g*) An efficient and flexible implicit finite difference solution of the one-dimensional equations of unsteady flow has been developed to form the basis of an operational model for predicting stages and discharges in rivers and estuaries. The model has powerful data handling features and has been successfully tested on the Ohio-Mississippi Rivers and the lower Columbia River. An efficient automatic calibration program has been developed to serve as a convenient procedure for calibrating the operational model.
(*h*) **Implicit Dynamic Routing of Floods and Surges in the Lower Mississippi**, D. L. Fread, presented *AGU*, 1974. Available Hydrologic Research Lab., W23, Natl. Weather Service, NOAA, Silver Spring, Md. 20910.
Flood Routing in Meandering Rivers with Flood Plains, D. L. Fread, *Rivers 1976, Symp. Waterways* **I**, Fort Collins, Colo., pp. 16-35, Aug. 1976.
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U.S. DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION, DIVISION OF GENERAL RESEARCH, Attention 1530, Denver Federal Center, Denver, Colo. 80225. Howard J. Cohan, Division Chief. (Address all inquiries to Division Chief.)

322-06321-340-00

DRAFT TUBE SURGES

(*d*) Theoretical and experimental; basic and applied research.
(*e*) Surging flow in draft tubes of Francis turbines causes rough operation and often produces power swings. The surging flow is produced by vortex breakdown, creating an unsteady flow condition. The purpose of the project is to investigate the basic nature of draft tube surging, to correlate model test and field test data, and to investigate air injection and speed variations as a means of reducing the magnitude and range of the surging.
(*g*) In a laboratory air model, surge data were obtained for over 50 draft tube shapes, including draft tube models, straight circular cylinders, truncated diverging cones, and circular cross-section elbows. The studies show that the degree of divergence of the draft tube throat is the most significant geometric feature affecting surging characteristics. Bends and length have lesser influence. Increasing the draft tube throat expansion angle generally reduces the range of surging as well as reducing the amplitude of surging. The draft tube surge range of a model turbine has been defined and limited prototype correlation data have been obtained. The swirl momentum method has not been refined to allow general prediction of the limits of the surging range.
(*h*) **Model and Prototype Turbine Draft Tube Surge Analysis by Swirl Momentum Method,** U. J. Palde, *IAHR Symp.*, Vienna, Austria, Sept. 1974.

322-07022-340-00

GRAND COULEE PUMP-TURBINE INTAKE AND TRANSITION

(*d*) Experimental; for modification.
(*e*) Laboratory studies are continuing to determine the benefits which could be derived by lowering the floor of the Banks Lake Feeder Canal.
(*f*) Completed.
(*g*) The conduit exits, designed and built for pumped flow only, must be modified to operate satisfactorily as inlet-outlet structures for the pump-turbine concept. A satisfactory design developed by model study included reshaping 78 feet of the conduit exits, and adding one vortex-suppressing wing wall.
(*h*) Report in preparation.

322-07028-350-00

AUBURN SPILLWAY GATE STUDY

(*d*) Experimental; design.
(*e*) A 1:24 scale model was used to study the rectangular bellmouth entrance, downstream seal fixed-wheel gate, gate frame, and the conduit through the dam.
(*f*) Completed.
(*g*) The entrance shape produced positive pressures throughout its length. An elliptical frame which protruded into the flow downstream from the gate slots was developed to prevent cavitation damage in the frame area. An aeration offset downstream from the gate frame was developed to allow the jet to be aerated on all surfaces before reaching the sloping conduit. A slope was established for the downstream conduit to prevent filling of the bottom aeration offset for all heads and gate openings encountered. Hydraulic downpull data was obtained for the gate to place seal contact blockouts to eliminate areas of unstable vertical forces.
(*h*) Report in preparation.

322-07030-320-00

CANAL AUTOMATION

(*d*) Experimental development; applied research.
(*e*) Continue the development of controls for automation of water distribution systems.
(*g*) The EL-FLO plus RESET method of automatic downstream control has been permanently installed on two canal systems in California and has worked successfully for 2 years. Modifications were required to improve protection of electronic equipment during electrical storms. The development of prototype equipment for the "set-operate-variable-rest" method for upstream or downstream control of outlet works of diversion dams continues. The development of the "Harder-Smith Predictor Method" (HSPM) for automatic downstream control of canal check gates was started. The HSPM is a highly responsive control system and has the potential of being competitive to remote supervisory control systems.
(*h*) **Stability of Automatic Canal Systems Utilizing the Frequency Response Method,** C. P. Buyalski, Dr. H. T. Falvey, *Intl. Assoc. Hydraulic Research (IAHR), Symp. Fluid Motion Stability in Hydraulic Systems With Automatic Regulators,* Bucharest, Romania, 10 pages, Sept. 26-29, 1976.

322-07035-350-00

AUBURN DAM SPILLWAYS

(*d*) Experimental; design.
(*e*) A 1:72 model is used to study flow conditions in the chutes, stilling basins, and river channel. The service spillway is located on the left abutment and discharges into a hydraulic jump stilling basin. The emergency spillway on the right abutment terminates in a flip bucket. Each spillway discharges up to 160,000 cfs through controlled orifices located up to 150 feet below the maximum water surface. The model is also being used to determine optimum sequencing of the orifices.
(*f*) Completed.
(*g*) Tests confirmed that the hydraulic jump energy dissipator for the service spillway was satisfactory. Testing was continued to develop alternate means for distributing the flow from the service spillway. Efforts have been directed toward terminating the chute about midway between the orifice spillway and the river channel. A flip-type bucket was developed to deflect the flow into an excavated plunge pool in the river channel.
(*h*) Report in preparation.

322-08472-750-00

ATMOSPHERIC SIMULATION

(*d*) Experimental; research.
(*e*) A study using salt water density gradients in a model to represent atmosphere.
(*f*) Completed.
(*g*) The technique of simulating atmosphere with a stratified liquid was satisfactory. The results were verified by observations of field data. A detailed flow field for three atmospheric conditions was determined for a field site.
(*h*) **Atmospheric Simulation Using Stratified Liquid Models,** H. T. Falvey, R. A. Dodge, *REC-ERC-77-8*, 1977.

322-09379-390-00

HAVASU PUMPING PLANT INTAKES AND SUCTION TUBES

(*d*) Experimental; design.
(*e*) A 1:9.4-scale model was used to study flow conditions in the approach channel to the pumping plant, through the suction tube intakes, and through the suction tubes. Each of the six units in the plant has a maximum discharge of 500 ft^3/s with a vertical lift of approximately 800 feet. The pumps have a submergence of approximately 70 feet with a resulting suction tube length of approximately 140 feet. The effects of the sequence of pump operation and the intake water surface elevation were considered.
(*f*) Completed.
(*g*) Tests confirmed that the suction tube design was satisfactory, yielding quite uniform flow with only slight rotation at the pump eye. For the two suction tube intakes studies (gate sections of 9 feet by 9 feet and 9 feet by 12.5 feet) no difference was observed in their hydraulic performance. At various operating conditions vortex tendencies were observed above the suction tube intake. Placement of the trash-racks on the intakes reduced the intensity of the vortices and eliminated the potential for air to be drawn into the suction tubes. A unit sequencing was found to minimize adverse flow patterns in the intake channel.
(*h*) **Hydraulic Model Studies of the Intake and Suction Tubes for Havasu Pumping Plant, Central Arizona Project, Arizona,** P. O. Johnson, *Rept. GR-19-76*, Oct. 1976.

322-09380-340-00

TWIN LAKES PUMPED STORAGE PROJECT

(*d*) Experimental; design.
(*e*) Two models were used to determine the effect of the pumping and generating flow on a natural lake used as the afterbay during the generating cycle and forebay for the pumping cycle. A distorted model (1:100 vertical - 1:600 horizontal) was made of the recipient lake and a connected companion lake which was thermally stratified and the effect of several weeks of plant operation on the stratification was determined. The second model was undistorted on a 1:100 scale and contained the pumping-generating plant and a section of the recipient lake. This model was to determine the best configuration for the channel between the plant and lake to prevent the flow from disturbing glacial flow deposits on the bottom of the lake.
(*f*) Completed.
(*g*) An alinement for a channel between the pumping-generating plant and the lake was developed that withdrew water from middepth in the lake during the pumping cycle and influenced the inflowing jet during the generating cycle so that it had less tendency to move along the bottom of the lake. Flow was well distributed across the channel as it entered the lake during the generating cycle. During the pumping cycle the flow entered the channel along the left bank of the lake but was evenly distributed by the time it reached the plant. The glacial flour deposits on the bottom of the lake should not be disturbed by plant operation. This configuration had only minor influence on temperatures and stratification in the lower lake.
(*h*) Report in preparation.

322-09382-350-00

STEWART MOUNTAIN SPILLWAY

(*d*) Experimental; design.
(*e*) A 1:72 model was used to study flow patterns across a rock surface downstream from the spillway chute. The spillway, which is 265 feet wide and 450 feet long, will pass a maximum discharge of 140,000 ft^3/s. The flow returns to the river from the spillway chute by passing over the granite terrain. When the chute was constructed in 1936 it was thought that the rock was adequate to prevent significant erosion. This has not proven to be the case and now the chute structure is being compromised. The study was done to find a solution that would reduce and protect against adverse hydraulic action on the rock.
(*f*) Completed.
(*g*) Tests developed an excavated topography that eliminated adverse hydraulic action at poor rock zones near the chute structure. Impact pressures and flow velocities were determined for use in the design of protective surfacing.
(*h*) **Hydraulic Model Studies of Stewart Mountain Dam Spillway,** P. L. Johnson, *Rept. GR-6-75*, July 1975.

322-09383-360-00

LOW FROUDE NUMBER STILLING BASINS

(*d*) Experimental, applied research.
(*e*) Studies are being performed to generalize a hydraulic jump-type stilling basin for spillway flows having an enter-

ing Froude number less than 4.5. Studies will be directed to determining dimensions and appurtenances that will provide effective energy dissipation in the basin and smooth water surface downstream from the basin. Parameters will be reduced to dimensionless relationships and will be a supplement to the USBR Monograph No. 25, "Hydraulic Design of Spillways and Energy Dissipators."
(*f*) Completed.
(*g*) A basin has been developed for a specific project with Froude number of about 3.0. Studies are continuing for a different slope on the entrance chute and other Froude numbers.
(*h*) **Low Froude Number Stilling Basin for Spillway Flows, R. L. George**, in preparation.

322-09384-390-00

ICE RESEARCH

(*d*) Experimental, field research.
(*e*) To improve designs and to reduce expenses of operating and maintaining water resource projects in cold regions. Present areas of investigations include frost action, ice jam observations, coatings to reduce ice adhesion, and development of a supercooled water temperature measuring device.
(*h*) **Prevention of Frazil Ice Clogging of Water Intakes by Application of Heat**, T. H. Logan, *Rept. REC-ERC 74-15*, Sept. 1974.
Design and Operation of Shallow River Diversions in Cold Regions, R. B. Hayes, *Rept. REC-ERC 74-19*, Sept. 1974.

322-09385-210-00

HORIZONTAL MULTIJET SLEEVE VALVE

(*d*) Basic research; development.
(*e*) The multijet sleeve valve has potential for use in pressure systems of municipal and industrial water supply lines for dissipation of pressure heads up to 500 feet. The investigation involves sizing the multijet ports and stilling chamber and determining the discharge coefficients for the valve and stilling chamber.
(*f*) Completed.
(*g*) A multijet sleeve has been developed where a combination of nozzles and slots are used to efficiently pass the design flow.
(*h*) **Hydraulic Tests and Development of Multijet Sleeve Valves**, P. H. Burgi, report in preparation.

322-09388-850-00

McCLUSKY CANAL FISH SCREEN

(*d*) Experimental; design.
(*e*) A full scale sectional model was used to study the performance of a screen structure designed to stop the passage of fish, fish eggs, and fish larvae. Laboratory tests were conducted to optimize the screen size while maintaining adequate screening and self-cleaning. The prototype structure will pass a maximum design discharge of 1,950 ft^3/s.
(*f*) Completed.
(*g*) The purpose of the study was accomplished and the prototype structure is now under construction.
(*h*) **Hydraulic Model Study of a Fish Screen Structure for the McClusky Canal**, P. L. Johnson, *Rept. REC-ERC-75-6*, Dec. 1975.

322-09389-390-34

HYDRAULIC MODEL STUDIES FOR BACKFILLING MINE CAVITIES

(*b*) U.S. Bureau of Mines.
(*c*) E. J. Carlson, Code 1532.
(*d*) Experimental; applied research.
(*e*) Hydraulic models of idealized coal mines were tested to demonstrate the pattern of deposition of sand and coal waste material by pumping slurries of fine sand and of coal waste in water into the mine cavities. Distorted scale and undistorted scale models have been tested. The most recent tests were conducted with a 1 to 48 undistorted scale for various types of coal mine conditions including two mines, one above the other.
(*g*) Soil mechanics tests of both fine sand and coal waste backfill materials to be used in the field have been made. Bearing strengths expected to develop for resistance to subsidence at the surface have been determined.
(*h*) **Hydraulic Model Studies For Backfilling Mine Cavities**, E. J. Carlson, *REC-ERC 73-19*.
Hydraulic Model Studies for Backfilling Mine Cavities (Second Series of Tests), E. J. Carlson, *REC-ERC-75-3*.
Report in preparation for test with the two mine levels.

322-09390-220-00

CONTROL OF TURBIDITY OF CONSTRUCTION SITES

(*d*) Experimental; applied research.
(*e*) A study team was assembled to review current methods and techniques currently used for control of turbidity at construction sites. Research projects will be conducted in areas related to turbidity control where information is lacking.
(*g*) Ongoing research and factual information concerning turbidity and presently used methods of measurement and control of turbidity were assembled. A report is being prepared which will be made available to planners, designers, construction engineers, and other field construction personnel.
(*h*) **Control of Turbidity at Construction Sites**, E. J. Carlson, *3rd Federal Interagency Sedimentation Conf.*, 1976.
Environmental Control During Construction, J. C. Peters, *Internal Report*.

322-09391-840-00

FLOW INTO INTERCEPTOR DRAINS ON SLOPING LAND NOT INSTALLED PERPENDICULAR TO THE WATER TABLE GRADIENT

(*d*) Experimental; applied research.
(*e*) Field experience has shown that agricultural drains installed on an angle not perpendicular to the water table gradient are not effective when installed according to criteria for drains on level land. A 60-foot long, 2-foot wide, 2-1/2 foot-deep sand tank whose slope can be adjusted up to 12 percent will be used to determine adjustments in drain spacing that are necessary.
(*g*) Tests with drains at a 45° angle to hydraulic gradient with gradient slopes up to 10 percent have been tested.
(*h*) Report in preparation.

322-09393-350-00

HYDRAULIC MODEL STUDIES OF PALMETTO BEND DAM SPILLWAY

(*d*) Experimental; for design.
(*e*) Hydraulic model studies aided in the design of the inlet channel to the spillway, the stilling basin, and the channel downstream from the spillway.
(*f*) Completed.
(*g*) Tests with a 1:100 scale overall model resulted in verification and slight changes to the initial design. The inlet channel was widened and a bend of the inlet channel placed further upstream. To improve flow entering the left side of the spillway a dike was placed upstream from the dam along the left side of the inlet channel. Length of the stilling basin was reduced by 30 feet and elevation of the floor raised 5 feet. Also it was found beneficial to add floor blocks and a dentated end sill to the stilling basin. Water flowed from the stilling basin onto a flood plain. Embankments were placed on each side of the stilling basin downstream for a 400-foot distance to channelize water leaving the spillway. The embankments prevented excessive circulation eddies near each end of the stilling basin. Because of the low Froude number stilling basin a 1:30 scale sectional model was used to finalize the design of the floor blocks and dentated end sill.
(*h*) Report in preparation.

322-09394-840-00

DRAIN ENVELOPE STUDIES

(*d*) Applied research.
(*e*) A corrugated plastic drain tube, surrounded by a gravel envelope, was hydraulically tested and test results compared to an electrical analogy study. Present gravel envelope head loss design criteria are based on test results of the electrical analogy study, which did not simulate turbulent flow.
(*f*) Completed.
(*g*) Turbulent flow occurred for the hydraulic tests, but for discharges greater than normally occur with field drains. Flow through the gravel envelope for the hydraulic tests was 30 times greater than indicated by the electrical analogy study. This difference was caused by nonhomogeneity of the gravel envelope medium in the hydraulic tests. The gravel did not completely fill corrugations of the plastic drain tubing and large particles formed stratifications in the envelope. Water more readily flowed through the less dense portion of the gravel envelope than current through the uniformly resistive conductor of the electrical analogy tests.
(*h*) Report in preparation.

322-10672-210-00

CORRUGATED PLASTIC DRAIN TUBING

(*d*) Applied research.
(*e*) Friction, grade deviation, and limited sedimentation tests were made using an 18-m (60-ft) length, 100-mm (4-in) diameter, nonperforated corrugated plastic drain tube. Four bends, 2.4 m (8 ft) long, with one- and two-tube diameter offsets above and below grade, formed the grade deviations; and a fine uniform 0.2-mm mean diameter sand was used for the sedimentation tests.
(*f*) Completed.
(*g*) Mannings "n" varied from 0.015 to 0.016 for full-tube flow and from 0.015 to 0.018 for free-surface flow. Only with bends above grade, and for conditions of free-surface flow, was the hydraulic gradeline seriously affected. The hydraulic gradeline raised upstream from the bend, approximately the amount of the bend offset. The sediment did not prevent waterflow through a two-diameter offset bend below grade, with a 0.001 slope of the straight tubing.
(*h*) Report in preparation.

322-10673-340-00

GRAND COULEE THIRD POWERPLANT–VORTEX STUDY

(*d*) Experimental; for design.
(*e*) A 1:120-scale model was used to study whether air-entraining vortices would form near the penstock intakes and study the use of rafts for preventing formation of air-entraining vortices.
(*f*) Completed.
(*g*) Vortex modeling is difficult because of lack of similitude between model and prototype. A literature search disclosed an Equal Velocity Method of vortex modeling and this method was used in the study. Without model trashracks, air-entraining vortices readily formed, and with model trashracks, vortex action was reduced. Rafts, either floating or submerged, suppressed vortex formation. Investigations were made to determine the prototype area in the forebay that may be susceptible to vortex action and may need raft protection.
(*h*) **Hydraulic Model Vortex Study–Grand Coulee Third Powerplant,** E. R. Zeigler, *Rept. REC-ERC-76-2*, Feb. 1976.

322-10674-350-00

ABRASIVE MATERIALS IN STILLING BASINS

(*d*) Applied research.
(*e*) Some stilling basins have required expensive repairs because of abrasive materials circulating with the water. These materials entered the basins in different ways; water circulation at the downstream end of the basin draws rock into the basin, rock and debris thrown in by spectators, and/or debris left by the contractor. Hydraulic model studies may show design changes that will provide better flushing and lessen the tendency for material to be drawn from downstream into the basin. However, information is needed before starting laboratory studies. A survey will be made of Bureau of Reclamation stilling basins to determine what structures have abrasion problems. If possible, whether the material entered by man or flowing water, if by flowing water from what source, the location and extent of damage, and operating conditions causing the damage.

322-10675-350-00

CURECANTI DROP PIPE, SPIRAL FLOW INTAKE, AND STILLING BASIN

(*d*) Experimental; for design.
(*e*) A 1:22.5-scale model was made of the 142-m-high drop structure to develop a spiral flow intake to force the flow to cling on the wall of the 2286-mm-diameter vertical pipe and to provide satisfactory stilling basin.
(*g*) The intake dropped the flow at 55° and converged at 15° on both sides to form a tangential slot 0.305 metres wide. The flow remains spiral for about 40 metres. The remaining fall is straight but the flow clings to the wall. The stilling basin was about 5 metres deep and long. A wave suppressor was needed to dampen wave action.
(*h*) Report to be prepared.

322-10676-350-00

BLANCO DIVERSION DAM

(*d*) Experimental for rehabilitation design.
(*e*) A 1:16-sediment model was used to develop a sediment excluding system to prevent coarse sediment from abrading the diversion tunnel and to make sluicing operations less obtrusive downstream. A large portion of the sediment gradation was scaled to account for armoring.
(*f*) Completed.
(*g*) A trapping system requiring more frequent sluicing of smaller quantities of sediment was developed. The trapping system reduced tunnel sediment intake by about 25 percent.
(*h*) Report in preparation.

322-10677-350-00

KLANG GATES DAM

(*d*) Experimental for design of modification to enlarge reservoir capacity.
(*e*) A 1:36-scale model was used to determine if the spillway and stilling basin would still be adequate after adding four top-seal radial gates to increase the maximum reservoir elevation about 7 metres.
(*f*) Completed.
(*g*) Pressure measurements indicated no excessively low pressures. Calibrations were provided for the gates which were located just downstream of the ogee crest. Optimum gate operations for one- and two-gate combinations for low discharges were determined.
(*h*) In-house memorandums.

322-10678-320-00

HYDRAULIC STUDIES OF STEEP CANAL LATERALS

(*d*) Experimental; applied research.
(*e*) Small, unreinforced, concrete-lined, trapezoidal cross-section canal laterals with maximum flow velocities less than 5 m/s and with maximum discharges less than 1 m^3/s are often used on irrigation projects. The grades of these laterals of concern tend to follow the ground surface and, thus, flow velocities vary. Both subcritical and supercritical flows may occur in the same lateral reach. Studies are being conducted to evaluate wave heights developed by undular hydraulic jumps on these laterals and to evaluate uplift pressures that develop under the lining, at lining breaks, and offsets.

(*g*) The first phase of testing is complete. Based primarily on a literature search, curves have been developed which allow evaluation of undular jump wave heights, wavelengths, and jump position. Based on flume tests, curves have also been developed which relate maximum uplift pressure development to various combinations of vertical and horizontal lining offset and to flow velocity over the offset. This work, to date, is based on a two-dimensional model study.
(*h*) Two internal memorandums serve as reports on the completed first phase work.

322-10679-860-00

DESTRATIFICATION DIFFUSER EFFICIENCY TESTS

(*d*) Field investigation; applied research.
(*e*) A 210-metre-long compressed air line diffuser is being operated at a $3 \times 10^8 m^3$ reservoir. Total energy input from the diffuser and reservoir stability are being closely monitored. Historical records of reservoir stability prior to diffuser operation are available. The objective of the study is to evaluate the influence of unit air flow rate on total diffuser mixing efficiency. Laboratory data are being used to augment field data.
(*g*) Diffuser is installed and is operating. Field data are being collected.

322-10680-350-00

STEWART MOUNTAIN DAM, HIGH TAILWATER STUDY

(*d*) Experimental; design.
(*e*) A new dam may be built downstream of Stewart Mountain Dam. Under severe flooding the new reservoir could cause very high tailwater at Stewart Mountain. A 1:72-scale hydraulic model is being used to study the influence of the tailwater on the hydraulic performance of the structure. Of primary interest is the spillway which has a radial gate-controlled crest and a chute which contains a superelevated horizontal bend. The tailwater may actually rise above the crest. Flow conditions which could undercut or endanger the structure are of primary interest.
(*g*) The model is constructed and testing is underway.

322-10681-350-00

POT HOOK MORNING GLORY SPILLWAY

(*d*) Experimental; design.
(*e*) A 1:24-scale hydraulic model is being used to develop a morning glory spillway design. The maximum discharge for the spillway will be 145 m^3/s. Approach flow conditions to the spillway crest, vortex suppression, pressures on the crest, shaft, and vertical bends, tunnel deflectors, air demand, and approach flow conditions to the stilling basin will all be evaluated.
(*g*) The model is constructed and testing is about to begin.

322-10682-350-00

MODIFICATION OF NAVAJO DAM AUXILIARY OUTLET WORKS AND BYPASS TO REDUCE DISSOLVED GAS SUPERSATURATION

(*e*) A 1:48-scale hydraulic model was used to refine and evaluate modifications to the auxiliary outlet works and 762-mm, hollow-jet valve bypass. The structures are being modified to reduce high dissolved gas supersaturation levels which have resulted during operation. Depth of jet penetration, degree of energy dissipation, strength of back eddies returning into the stilling basin, potential for cavitation development, and design simplicity were factors considered.
(*f*) Completed.
(*g*) It was observed that both unmodified structures caused deep penetration of their release flow into the stilling basin pool. By flattening the angle of release of the hollow-jet valve, and by placing a flip lip on the auxiliary outlet works, this penetration was greatly reduced. It is expected that this will, in turn, greatly reduce resulting dissolved gas supersaturation levels. The final modifications were also found to be hydraulically acceptable with respect to the other parameters considered.
(*h*) **Hydraulic Model Studies of Navajo Dam Auxiliary Outlet Works and Hollow-Jet Valve Bypass–Modifications to Reduce Dissolved Gas Supersaturation,** P. L. Johnson, *Rept. REC-ERC-76-5*, Apr. 1976.

322-10683-350-00

PACHECO

(*d*) Experimental; applied research.
(*e*) A 1:11.54 hydraulic model of the high pressure slide gate and stilling basin was constructed and tested to develop a satisfactory design for these components of the Pacheco tunnel. The discharge of the tunnel could vary from less than 1.1 m^3/s (40 ft^3/s) to 13.6 m^3/s (480 ft^3/s). The maximum head on the slide gate was 73.8 m (242 ft) of water. The effect of the high velocity discharge from the slide gate was studied.
(*f*) Completed.
(*g*) The control structure of the Pacheco tunnel is a 1.52-m × 2.14-m (5-ft × 7-ft) high pressure slide gate with a stilling basin immediately downstream. The initial design performed satisfactorily except for subatmospheric pressures downstream from the control gate and on the energy dissipator baffle piers. The subatmospheric pressures occurred only for heads above 67.1 m (220 ft) of water and gate openings between 3 and 8 percent. An elliptical section 152 mm (6 in) wide was placed on both sidewalls donwstream from the gate slot, which raised the pressures downstream from the gate. Also, the bypass was enlarged to a 508-mm (20-in) pipe so that the gate would not be required to operate at gate openings less than 5 percent open. The potential cavitation pressures measured on the original round-top baffle pier were minimized by using a modified flattop baffle pier, which resulted in pressures only slightly below atmospheric.

322-10684-350-00

CHOKE CANYON

(*d*) Experimental; design.
(*e*) A 1:80-scale model was used to study the stilling basin and the approach channel to the spillway. The spillway will be about 112 metres wide and will have a maximum discharge of 7100 m^3/s. A stilling basin was designed according to the criteria developed for low Froude number stilling basin and is being tested in the model.

322-10685-340-00

PENSTOCK ENTRANCE RESEARCH

(*d*) Experimental; applied research.
(*e*) Hydraulic model studies are being conducted to aid in the development of design criteria for economical, efficient penstock entrances.
(*g*) Tests on a 1:15.74 model have confirmed the proposed penstock entrance design for Auburn Dam. Several modified entrances will be studied to determine the effects of various entrance configurations on head loss, pressure distribution on the entrance flow surfaces, and velocity distribution in the penstock.

322-10686-390-00

CLAMSHELL GATE

(*d*) Experimental; development.
(*e*) A 203-mm (8-in) clamshell type flow control gate is being tested to determine its operating characteristics. The gate is free of slots or offsets in the flow passage, eliminating cavitation to the valve body. A high discharge coefficient equal to that of a wide open pipe results when the valve is in the fully open position.
(*g*) Tests have been completed on the valve for free releases. Spray results for some partial openings; however, the main body of the jet is well directed. Light walls would be adequate for confining the spray. The valve is being modified for submerged releases.

322-10687-350-00

AMALUZA DAM SPILLWAY

(*d*) Experimental for design.
(*e*) A 1:70 model was used for radial gate calibration, design of the overfall spillway, and the study of the downstream riverbed scour.
(*f*) Completed.
(*g*) The capacity of the six radial gates was determined for flows up to a maximum of 7724 m^3/s at a head of 13.5 m above the crest. The spillway was designed for the steepest acceptable fall to produce the thinnest possible section for the thin arch dam. A flip bucket 114.5 m below the crest was designed to flip the flow a minimum of 125 m away from the toe of the dam and aline the jet along the river centerline.
(*h*) **Hydraulic Model Studies of the Amaluza Dam Spillway, Paute Project, Ecuador, South America,** D. Colgate, *Rept. GR-25-76*, Dec. 1976.

322-10688-820-00

GRAVEL PACKS AND WELL SCREENS FOR WATER WELLS

(*d*) Experimental; applied research.
(*e*) A 4.88-m (16-ft) deep, full-scale, simulated water well has been constructed in the hydraulic laboratory to test gravel packs and well screens. Forty-five piezometers were installed on five levels to measure pressures inside the well screen in the gravel pack and in the base aquifer material. A full-scale pump and piping system recirculates water from a sump, through the aquifer and gravel pack, into the well. Discharge is measured with a magnetic flowmeter. A mini (MAC) computer system is used to obtain data rapidly and store it on magnetic tape.

322-10689-370-47

BICYLE SAFE GRATE INLETS

(*b*) Federal Highway Administration.
(*c*) P. H. Burgi, Code 1531.
(*d*) Experimental; development.
(*e*) The purpose of this study was to develop new designs and/or improve existing designs of grate inlets on paved roads to maximize bicycle safety, hydraulic efficiency, and freedom from clogging. Over 500 bicycle and pedestrian safety tests were conducted on 11 test grates. Eight of these grates were selected for an indepth investigation of their hydraulic performance. Debris tests were also conducted to determine the clogging tendencies of each grate design.
(*h*) **Bicycle-Safe Grate Inlets Study, Vol. 1–Hydraulic and Safety Characteristics of Selected Grate Inlets on Continuous Grades,** *FHWA-RD-77-24*, in preparation.

322-10690-320-00

FREQUENCY-RESPONSE ANALYSIS OF AUTOMATED CANALS

(*c*) Henry T. Falvey, Code 1530-A.
(*d*) Theoretical; applied research.
(*e*) The determination of parameters for feedback controllers on automated canals is frequently a trial-and-error procedure. The purpose of the project was to develop an analysis method using modern control theory which would facilitate the parameter determinations.
(*f*) Completed.
(*g*) The project resulted in the application of classical frequency-response analysis methods to canals. Nonlinear effects are considered. With this method, the control parameters can be readily determined.
(*h*) **Frequency-Response Analysis of Automated Canals,** H. T. Falvey, *REC-ERC-77-3*, 1977.

322-10691-230-00

MECHANICS AND PREVENTION OF CAVITATION EROSION

(*d*) Experimental and field investigation.
(*e*) This study was undertaken to investigate methods of preventing cavitation damage to surfaces subjected to high velocity flow. Inadvertent misalinements or roughnesses wich may cause cavitation include such surface conditions as offsets, waviness, depressions, protrusions, bug holes, and surfaces that slope or curve too rapidly away from the flow. Design features such as gate slots and dentates may also cause cavitation and the protection of flow surfaces in the vicinity of such features is included in the study.
(*g*) Field tests have been made to determine the effectiveness of an aeration slot in a spillway tunnel to prevent cavitation damage to concrete subjected to high velocity flow. Studies have been completed to evaluate aeration slots or other configurations to draw air into a high velocity stream for surface protection. An aeration device has been installed in a prototype structure and a second is presently being installed in an outlet works where cavitation damage has occurred annually. Selected hydraulic structures in which cavitation damage has occurred will be observed as opportunities arise.
(*h*) Report in preparation.

322-10692-360-00

BAFFLED SPILLWAY ENERGY DISSIPATOR

(*d*) Experimental; for design.
(*e*) Laboratory studies were performed to develop a baffled spillway to be used when conventional energy dissipators might not be appropriate due to marginal siting conditions.
(*f*) Completed.
(*g*) Test determined that the design criteria used for the canal drop type baffled aprons with a limiting unit discharge of 5.6 m^3/s per metre of width (60 ft^3/s per foot of width) could be extrapolated to a spillway use with a unit discharge of 28 m^3/s (300 ft^3/s or greater. Construction difficulties and physical size of the structure seem to be the only limiting conditions.
(*h*) Report in preparation.

U.S. DEPARTMENT OF THE INTERIOR, GEOLOGICAL SURVEY, WATER RESOURCES DIVISION, 12201 Sunrise Valley Drive, Reston, Va. 22092. J. S. Cragwall, Jr., Chief Hydrologist.

323-0368W-200-00

TURBULENCE IN OPEN CHANNEL FLOW

(*c*) R. S. McQuivey.
(*e*) See Water Resources Research Catalog **9**, 2.0641.

323-0369W-220-00

TRANSPORT PROCESSES IN ALLUVIAL CHANNELS

(*c*) C. F. Nordin.
(*e*) See Water Resources Research Catalog **9**, 2.0336.

323-0371W-300-00

NUMERICAL SIMULATION OF HYDRODYNAMIC PROCESSES IN RIVERS, ESTUARIES, AND EMBAYMENTS

(*c*) R. A. Baltzer.
(*e*) See Water Resources Research Catalog **9**, 2.0956.

323-0372W-090-00

HYDRODYNAMIC STUDY ON THE TRANSPORT OF THERMAL, PHYSICAL, AND CHEMICAL CONSTITUENTS IN TURBULENT SURFACE WATER

(*c*) N. Yotsukura.
(*e*) See Water Resources Research Catalog **9**, 2.0965.

323-0373W-220-00

SEDIMENT MOVEMENT AND HILLSLOPE MORPHOLOGY IN THE CENTRAL APPALACHIAN REGION

(*c*) G. P. Williams.
(*e*) See Water Resources Research Catalog **9**, 2.0966.

323-0375W-810-00

PHYSICAL MODELING OF HYDROLOGIC SYSTEMS

(*c*) V. R. Schneider.
(*e*) See Water Resources Research Catalog **9**, 6.0514.

328-0377W-740-00

NUMERICAL SIMULATION OF HYDRODYNAMIC PHENOMENA BY DIGITAL COMPUTER

(*c*) V. C. Lai.
(*d*) See Water Resources Research Catalog **9**, 6.0992. See also 332-08481-740-00 in 1972 HRUSC.

323-0457W-300-00

CHANNEL ADJUSTMENTS DOWNSTREAM FROM COCHITI DAM ON THE RIO GRANDE, NEW MEXICO

(*c*) J. D. Dewey.
(*e*) See Water Resources Research Catalog **9**, 2.0740.

323-0458W-300-00

LONG TERM CHANNEL CHANGES

(*c*) L. B. Leopold.
(*e*) See Water Resources Research Catalog **8**, 2.0428.

323-0459W-860-00

WATER QUALITY MODEL DEVELOPMENT AND IMPLEMENTATION

(*c*) R. A. Baltzer.
(*e*) See Water Resources Research Catalog **9**, 5.1631.

323-0460W-220-00

ESTIMATION OF SEDIMENT YIELD AT UNSAMPLED SITES IN MISSOURI RIVER BASIN

(*c*) P. R. Jordan.
(*e*) See Water Resources Research Catalog **10**, 2.0258.

323-0461W-220-00

BEDLOAD TRANSPORT RESEARCH

(*c*) W. W. Emmett.
(*e*) See Water Resources Research Catalog **10**, 2.0254.

323-0462W-220-00

RATES AND PROCESSES OR EROSION AND SEDIMENTATION IN NATURAL AND DISTURBED FORESTED DRAINAGE BASINS OF THE PACIFIC COAST (ABBREV)

(*c*) R. J. Janda.
(*e*) See Water Resources Research Catalog **10**, 4.0005.

323-10693-860-00

OPERATIONAL MODELS OF SURFACE-WATER SYSTEMS

(*c*) M. E. Jennings.
(*d*) Experimental and applied research.
(*e*) The research objective is to develop operational digital models of surface-water systems. The models may be classified into four categories: (1) Overland flow, (2) channel flow, (3) lake and reservoir, and (4) estuary. Within each type of model both flow and water-quality processes will be considered. Flow processes will include hydrodynamics, stream routing, flow regulations, evaporation, and seepage. Water quality processes will include sedimentation production, transport and disposition, heat transfer, oxygenation and deoxygenation, and chemical and biological reactions.

323-10694-300-00

CHANGES IN VALLEY MORPHOLOGY, COON CREEK, WISCONSIN

(*c*) S. W. Trimble.
(*d*) Applied field research.
(*e*) To explain changes in stream and valley morphology that have occurred since the late 1930's in terms of stream sediment loads as related to changes in land use and/or climatic changes.

323-10695-860-00

MATHEMATICAL SIMULATION OF HYDROGEOLOGIC SYSTEMS

(*c*) R. L. Cooley.
(*d*) Basic research.
(*e*) The research objective is to evaluate presently used equations and, where necessary, (1) formulate new approximate equations pertaining to flow of fluids through porous or fractured rock emphasizing equations that are tractable for field use, (2) apply and (or) compare the best techniques available, or derive new ones, to solve the equations, (3) derive efficient techniques for estimations of parameters contained in the equations, (4) assess the degree of reliability and significance of both the model formed by the basic equations and the parameters estimated for it in terms of the input data, and (5) assess the degree of reliability and predictive capability of the model. The fundamental equations are developed utilizing the methods of mathematical physics together with basic physical concepts from geology, geochemistry, geophysics, etc. Solutions to the equations are to be developed analytically and (or) numerically, depending on the problem. Analysis of error propagation, stability, and convergence using techniques of linear and nonlinear algebra will accompany numerical solution procedures where feasible and appropriate. Parameter calculation is to be approached through techniques of nonlinear regression so that the reliability and significance of estimated parameters and the predictive capability of the model can be assessed.

323-10696-400-00

HYDRODYNAMIC AND MATHEMATICAL MODELING OF CIRCULATION AND TRANSPORT PHENOMENA IN A TIDAL ESTUARY

(*c*) R. T. Cheng.
(*d*) Basic and applied research.
(*e*) By means of computer simulation, a hydrodynamic and mathematical model of a tidal affected estuary will be developed. This model should provide sufficient resolution of the hydrodynamic characteristics describing a tidal affected ecosystem. The mathematical model will be general and will be calibrated and verified by actual field measurements. San Francisco Bay system will be considered as a test case; basic data will be collected to support the theoretical investigation, if necessary. Using a hydrodynamic study as a basis, the transport phenomena in this ecosystem will be modeled and verified.
Circulations in a tidal estuary are driven by tides, discharges of fresh water into the estuary, wind, gravity and density stratification. Topography of the estuary basin (3-dimensional), air-water interaction, turbulent mixing mechanisms, viscous resistance at the bottom and rotational effects of the earth, together with the above mentioned driving forces constitute a very complicated balance in order to conserve mass, momentum and energy of the system. At the beginning of this project, a simple model which preserves the most important features of the hydrodynamic characteristics will be considered. This computer program will be constantly implemented to bring the secondary mechanism into the model. A data collec-

tion program will be initiated which is designed mainly for the purpose of calibrating the mathematical model. Meteorological data, new modeling concept, new measurement techniques will be incorporated and updated throughout the course of investigation.

323-10697-300-00

INFLUENCE OF SEDIMENT AND OTHER VARIABLES ON ACTIVE-CHANNEL GEOMETRY

(*c*) W. R. Osterkamp.
(*d*) Basic and applied research.
(*e*) Information on the effect of particle size on channel shape, which can change in response to land use and hydraulic structures, is desirable for practical purposes. Knowledge of how sediment influences channel shape and stability can permit anticipation and correction of undesirable effects of man's activities.
The study will determine the controls that sediment exerts on the geometry of alluvial streams. The manner in which silt-clay content of bed and bank material influences the regression relation between channel geometry and discharge will be studied. Thus, the intention is to define the quantitative influence that sediment of a stream has on active-channel geometry, this information will result in better estimates of discharge from ungaged basins. Another objective is accumulation of field experience that will indicate the types of data leading to continued refinement of the channel-geometry method.
The study will have three phases: basic-data collection, data analysis, and report preparation. Active-channel widths and depths will be measured, and bed and bank samples collected at established gages of the Missouri River basin. Size analyses will be performed on the samples. Correlation of the geometry to discharge, bed silt-clay, and bank silt-clay, will be analyzed by computer (multiple regression). The equations developed will express the effect of sediment, and possibly other variables, on the channel geometry relation through a large range of climates and topographies. Results are expected to have wide transfer power.

323-10698-880-00

SEDIMENT YIELD OF STREAMS DRAINING THE PICEANCE BASIN, NORTHWESTERN COLORADO

(*c*) V. C. Norman.
(*d*) Applied research.
(*e*) Mining and associated activities have been shown to have a dramatic impact on the sediment yield of streams draining mined areas. In other areas, mining has been shown to increase sediment yield, alter channel geometry and channel morphology, and reduce the conveyance of streams. Prototype oil-shale development in the Piceance basin will involve the mining, processing, and disposal of over 150,000 tons of oil shale per day. Handling and disposal of such large quantities of spent shale may greatly increase the sediment load in streams.
Define the sediment yield of streams draining the Piceance basin and the lands that are scheduled to be mined, define the sediment yield prior to mining. This data will be used to determine the "natural" sediment yield of streams in the basin. After oil-shale mining begins, continue to collect data and define the sediment yield of streams from mined areas to evaluate the impact of oil-shale mining on sediment yield.
Install automatic suspended sediment samplers at key stations throughout the basin to define the sediment yield of the basin and streams draining the leased tract that are scheduled for oil-shale mining. In addition, monitor channel cross-sections and profiles on hillslope erosion transects established during the previous water resources investigation of the Piceance basin. Data from these stations will be used to define the "natural" sediment yield and monitor changes resulting from development. During the third year, the approach will be evaluated in light of objectives and current status of development and a proposal for continued funding will be prepared.

323-10699-300-00

SEDIMENT MOVEMENT AND CHANNEL CHANGES IN RIVERS

(*c*) R. H. Meade.
(*d*) Applied research.
(*e*) To assess: (1) Changes in river sediment loads over periods of decades or longer, and the factors (natural and artificial) that cause the changes; (2) Rates at which rivers change their courses, shapes, and other morphologic features, both in their natural state and in response to artificial influences; (3) Effects of infrequent catastrophic events or large-scale human influences on the "equilibrium" sediment movement and channel morphology in rivers; (4) Sources, pathways, and sinks of sediment in rivers.
Basically a historical approach, using available records and making some first-hand field studies. Records will include sediment-load data previously collected by USGS and other agencies; changes in channel morphology will be interpreted by comparing old and new maps plus available aerial photographs of selected rivers in the upper Missouri Basin. Field studies will include repeated surveys of selected channels and tracer studies of sediment movement.

323-10700-820-00

DIGITAL MODELING OF GROUNDWATER FLOW

(*c*) S. P. Larson.
(*d*) Basic and applied research.
(*e*) The objectives of this study are to develop new or to refine existing groundwater flow models for 3-dimensional problems. Optimum model efficiency in terms of computer core storage and computational work required is necessary to permit application to field problems. The resulting groundwater flow model will be used to determine 3-dimensional velocity distributions and subsequently prediction of 3-dimensional movement of contaminants in saturated porous media.
Various numerical techniques, such as SIP, ADI, and LSOR, will be evaluated as to their utility in solving 3-dimensional groundwater flow problems. An optimum combination of computer core storage and computational work required will be emphasized in the development of new models or refinement of existing models. This will require efficient programming of algorithms and use of computer techniques that minimize core storage requirements. Emphasis will also be placed upon making the resultant model or models applicable to a wide variety of field problems within constraints imposed by problem size and computational work.

323-10701-820-00

GROUNDWATER MOVEMENT AND HYDRODYNAMIC DISPERSION EVALUATED BY SINGLE-WELL TRACER INJECTION

(*c*) R. J. Sun.
(*d*) Experimental, basic and applied research.
(*e*) To properly evaluate sites for disposal of radioactive wastes it is necessary to estimate the actual groundwater flow velocity, the natural hydraulic gradient and the characteristics of hydrodynamic dispersion and the transmissivity of the system. These factors can be determined by pumping and tracer tests. For a preliminary site evaluation, it is usually proposed that enough information to evaluate a site be obtained by a single well, thus reducing the cost. It is believed, but needs to be verified, that a sin-

gle well can provide not only geological knowledge during drilling, the transmissivity during pumping, but also local groundwater velocity and hydraulic gradient during tracer injection.

Before using the single-well tracer injection for site evaluation, it is necessary to compare the results obtained both from single-well and multi-well tests to determine whether they will give the same or similar results for the system. Because the study will be conducted at a fractured reservoir, the second objective of the study is to determine whether hydraulic parameters of fractured rocks can be obtained by pumping test. An adequate mathematical model will be evaluated and/or developed to interpret pumping data obtained at a fractured reservoir.

Using the existing wells at the Amargosa site southwest of the Nevada Test Site to conduct the study, the following steps will be taken during the study: (1) modify the well conditions at the site; (2) at least 1 pumping and recovery test and 1 step-drawdown test will be made; (3) one two-well tracer test to determine hydrodynamic dispersion and effective porosity of the formation; (4) 2 single-well tracer injection tests to determine hydraulic gradient, dispersion and the actual groundwater velocity.

The technology developed at the test site can be used in site evaluation for waste disposal, whether the groundwater at the site flows through porous media or fractured rocks. The results of the research are not only applicable to low-level radioactive waste disposal problems, but are also applicable to other subsurface waste disposals.

323-10702-820-00

HYDRODYNAMICS AND GEOCHEMISTRY OF THE GULF COAST GEOPRESSURED AQUIFERS

(*c*) P. C. Trescott.

(*d*) Experimental; basic and applied research.

(*e*) The hot water aquifers in the Gulf Coast occur in geopressured zones in which the high pressure may be due to one or more of several possible mechanisms including: sedimentary loading at a rate greater than the rate water can migrate from the consolidating confining beds; clay mineral diagenesis (for example, dehydration of montmorillonite) generating pore fluids and affecting aquifer chemistry; membrane properties of clay that yield anomalous fluid pressures and affect dissolved solid concentrations in different zones by osmotic processes. The significant physical and chemical processes affecting this aquifer system need to be described theoretically and modeled numerically.

1) To describe the significant physical and chemical processes affecting groundwater flow in the Gulf Coast geopressured aquifer system; 2) to incorporate the significant physical and chemical processes into digital simulation models which can be used to evaluate the energy potential of the hot water aquifers.

Derive theoretical descriptions (and write numerical analogs for use in simulation models) of physical and chemical processes affecting the pressure and chemistry of the geopressured aquifer system. Included are: a mass balance/solution equilibria model for evaluation of the effects of clay mineral diagenesis; a model of clay membrane properties which evaluates osmotic effects in the system; evaluation of the effects of consolidation using existing consolidation models. The membrane model may require the measurement of membrane properties of clay in the laboratory and in the field. Use the models to describe the hydrodynamics of geopressured aquifers using pressure and geochemical brine data from wells in the Gulf Coast region.

323-10703-220-00

MEASUREMENT AND PREDICTION OF SEDIMENT TRANSPORT PHENOMENA

(*c*) D. W. Hubbell.

(*d*) Experimental and applied research.

(*e*) The objective is to develop, over a wide range of hydraulic conditions, in sand-bed and gravel-bed streams, means for predicting quasi-equilibrium bed configuration, sediment transport, and other pertinent hydraulic and sedimentologic variables. Emphasis is on providing definitive criteria for predicting bed forms which will permit better estimates of channel conveyance, mass-transfer coefficients, channel stability, and aggradation-degradation.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, AMES RESEARCH CENTER, Moffett Field, Calif. 94035. Dr. Hans Mark, Director.

324-10704-810-00

REMOTE SENSING FOR SNOW AND ICE MAPPING, AND IN-SITU SOIL MOISTURE

(*b*) Cooperative with U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; U.S. Geologic Survey; State of California Snow Surveys Branch; and University of California.

(*c*) Dr. William I. Linlor, Applications Division, MS 245-5.

(*d*) Experimental, theoretical, and field investigation; basic and applied research.

(*e*) Important factors in forecasting water runoff rate from snowpacks include the wetness state of the snow and the melting speed (i.e., net heat input rate to the snow). Percolation of meltwater through the snow as well as rainfall affect the wetness state. No automated instrumentation is presently available for measuring snowpack wetness. The present work is investigating methods for wetness determination, using microwave attenuation and phase shifts between a source and receivers. Natural snowpacks at the Central Sierra Snow Laboratory (Donner Summit) are employed. Radar backscatter measurements are also in progress to determine the electromagnetic characteristics of snowpacks, including the effects of layering, dielectric constant, and wetness. The information is to be applied in surface systems to provide assessment of watershed resources on a time-progressive basis, operated automatically, with data transmission via microwave links, or satellites. The microwave techniques are also intended for use in airborne and satellite-based systems.

(*g*) Three new methods for measuring the wetness of snow samples have been developed: (1) The change in capacitance value before and after freezing; (2) the ratio of displacement current to conduction current; and (3) the attenuation of a transmitted microwave beam. Vertical profiles of snow and earth wetness are obtained by the phase shift and attenuation of a microwave beam between a source and receivers, which move vertically in towers that are fixed in the snow and extend into the earth. The backscatter of microwave beams from the snow surface exhibits a diurnal variation of the order of 10 db, depending on the wetness of the region near the surface of the snow. The backscatter of the microwave beams varies with frequency because of interferometric effects of the snow layers and the earth, the magnitude being of the order of 20 db.

(*h*) **Snowpack Water Content by Remote Sensing,** W. I. Linlor, *Proc. Banff Symp.* **1,** pp. 713-726, 1973.

Remote Sensing and Snowpack Management, W. I. Linlor, *J. Amer. Water-Works Assoc.*, pp. 553-558, Sept. 1974.

Electronic Measurements of Snow Sample Wetness, W. I. Linlor, J. L. Smith, *Proc. Symp. Advanced Concepts and Techniques in the Study of Snow and Ice Resources*, Natl. Acad. of Sciences, Washington, D.C., pp. 720-728, 1974.

Microwave Profiling of Snowpack Free-Water Content, W. I. Linlor, M. F. Meier, J. L. Smith, *Proc. Symp. Advanced*

Concepts and Techniques in the Study of Snow and Ice Resources, Natl. Acad. of Sciences, Washington, D.C., pp. 729-736, 1974.
Electromagnetic Reflection from Multilayered Snow Models, W. I. Linlor, G. Jiracek, *J. Glaciology* **14,** 72, pp. 501-515, 1975.
Measurement of Snowpack Wetness, W. I. Linlor, J. L. Smith, M. F. Meier, F. D. Clapp, D. Angelakos, *Proc. 43rd Ann. Western Snow Conf.*, pp. 14-20, 1975.
Multilayered Models for Electromagnetic Reflection Amplitudes, W. I. Linlor, *NASA Tech. Rept. TR-438*, Dec. 1975.
Snow Wetness Measurements for Melt Forecasting, W. I. Linlor, F. D. Clapp, M. F. Meier, J. L. Smith, *Workshop on Operational Applications of Satellite Snowcover Observations, NASA Spec. Publ. SP-391*, pp. 375-398, 1975.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, LANGLEY RESEARCH CENTER, Langley Station, Hampton, Va. 23665. Donald P. Hearth, Acting Director for Space.

325-09395-420-00

WAVE REFRACTION MODELING OF THE BALTIMORE CANYON CONTINENTAL SHELF REGION AND MODEL VERIFICATION WITH REMOTE SENSING DATA

(*c*) Dr. Charles H. Whitlock, Marine Environments Branch, Mail Stop 272.
(*d*) Theoretical and experimental applied research.
(*e*) A first-order wave refraction model for the mid-Atlantic continental shelf region between 37.5° and 40° N latitudes is being developed, and remote sensing data are being taken in the region to provide data for verifying the model. Ocean waves are monitored from the edge of the continental shelf until they reach the shoreline to evaluate how the waves are modified by continental shelf bathymetry. This particular region was selected because it fits as a subgrid to a planned National Weather Service ocean wave forecasting system and can be used for coastal wave experiment under the planned SEASAT satellite.
(*h*) **Random-Access Technique for Modular Bathymetry Data Storage in a Continental-Shelf Wave-Refraction Program,** L. R. Poole, *NASA TM X-3018*, July 1974.
Comparison of Techniques for Approximating Ocean Bottom Topography in a Wave Refraction Model, L. R. Poole, *NASA TN D-8050*, Nov. 1975.
Transformation of Apparent Ocean Wave Spectra Observed from an Aircraft Sensor Platform, L. R. Poole, *NASA TN D-8246*, June 1976.
Comparison of Remotely Sensed Continental Shelf Wave Spectra with Spectra Computed by Using a Wave Refraction Computer Model, L. R. Poole, *NASA TN D-8353*, Dec. 1976.
Wave Refraction Diagrams for the Baltimore Canyon Region of the Mid-Atlantic Continental Shelf Computed by Using Three Bottom Topography Approximation Techniques, L. R. Poole, *NASA TM X-3423*, Dec. 1976.

325-09396-710-00

REMOTE SENSING OF COASTAL WATERS

(*b*) Joint Langley and Old Dominion University Project.
(*c*) Dr. Charles H. Whitlock, Marine Environments Branch, Mail Stop 272.
(*d*) Experimental, field investigation; applied research.
(*e*) Major effort has been to monitor suspended sediment (as a natural water tracer) and chlorophyll (as an indicator of water quality). Analysis techniques have been developed for measuring pollutants in water. Future efforts will be directed at automatic analysis of remotely sensed data, through the development of spectral signatures of pollutants, for monitoring water quality in the Coastal Zones.
(*f*) Completed.
(*h*) **Correlation of ERTS Multispectral Imagery with Suspended Matter and Chlorophyll in Lower Chesapeake Bay,** D. E. Bowker, P. Flerscher, T. A. Gosnik, W. J. Hanna, J. Ludwick, *NASA SP-327*, Mar. 1973.
Transmissometry and Suspended Matter in Lower Chesapeake Bay. Correlation with ERTS Multispectral Imagery, D. E. Bowker, P. Flerscher, T. A. Gosnik, W. J. Hanna, J. Ludwick, *Amer. Soc. Photogrammetry, Proc. Fall Convention*, Oct. 1973.
Evaluation of ERTS MSS Digital Data for Monitoring Water in the Lower Chesapeake Bay Area, D. E. Bowker, W. G. Witte, presented *4th Ann. Remote Sensing of Earth Resources Conf.*, Tullahoma, Tenn., Mar. 24-25, 1975.
An Investigation of the Waters in the Lower Chesapeake Bay Area, D. E. Bowker, W. G. Witte, P. Fleischer, T. A. Gosink, W. J. Hanna, J. C. Ludwick, presented *10th Intl. Symp. Remote Sensing of Environment*, Ann Arbor, Mich., Oct. 6-10, 1975.
Evaluation of Water Samples Collected During Landsat-I Overpasses of the Lower Chesapeake Bay Area, D. E. Bowker, W. G. Witte, *The Institute of Electrical and Electronics Engineers, Inc., Annals No. 75CH1004-1 16-3*.
The Use of ERTS-I to More Fully Utilize and Apply Marine Station Data to the Study and Productivity Along the Eastern Shelf Waters of the United States, H. G. Marshall, D. E. Bowker, W. G. Witte, *Final Report for the Period August 1972–December 1974*, prepared under Contract NAS5-21816, Feb. 1976.
Correlation of Chlorophyll Suspended Matter, and Related Parameters of Waters in the Lower Chesapeake Bay Area to Landsat-1 Imagery, P. Fleischer, T. A. Gosink, W. J. Hanna, J. C. Ludwick, D. E. Bowker, W. G. Witte, Inst. of Oceanography, Old Dominion Univ., Norfolk, Va., *Tech. Report No. 28*, Aug. 1976.

325-09397-860-00

THREE-DIMENSIONAL NUMERICAL WATER QUALITY MODEL FOR CONTINENTAL SHELF APPLICATION

(*b*) Joint Langley and University of Rhode Island Project.
(*c*) Mr. Albin O. Pearson, Head, Marine Environments Branch, Mail Stop 272.
(*d*) Numerical, applied research.
(*e*) An alternating-direction implicit finite difference computational scheme is being used to develop a numerical model of the three-dimensional, time dependent continental shelf mass transport equation for water quality parameters. The model is being verified using one-, two-, and three-dimensional analytical solutions and by predicting the distribution of coliform concentration in the tidal portion of the Providence River. The verified model will then be employed to study the optimum location of a sewage outfall for New Shoreham in Block Island Sound.
(*h*) **Derivation of a Three-Dimensional Numerical Water Quality Model for Estuary and Continental Shelf Applications,** M. L. Spaulding, *NASA TM X-71930*, 1974.

325-09398-870-00

NUMERICAL-ANALYTICAL POLLUTION TRANSPORT MODEL FOR ESTIMATING ENVIRONMENTAL PARAMETERS FROM REMOTE SENSING DATA

(*c*) Mr. Albin O. Pearson, Head, Marine Environments Branch, Mail Stop 272.
(*d*) Theoretical, applied research.
(*e*) The mass diffusion equation is being solved by using a numerical quadrature formulation of the advection transport effects and an analytical formulation of the diffusion transport effects. The resulting solution is being used to develop simplified models of the pollution dispersion from point and area sources in uniform flows with and without shear. The models will be used to study techniques for estimating environmental parameters from remote sensing data. Parameters included are diffusion coefficients, velocity vectors, velocity gradients and pollutant source strength and location.

(*f*) Suspended.
(*h*) **An Integrated Approach to the Study of Pollution Transport and Waves in the Coastal Zone–Part II–Modeling,** G. R. Young, C. H. Whitlock, T. H. Rees, J. T. Suttles, R. E. Turner, presented *IEEE Intl. Conf. Engrg. in the Ocean Environment*, Halifax, Nova Scotia, Canada, Aug. 21-23, 1974.

325-09399-450-00

CONTINENTAL SHELF CIRCULATION MODEL DEVELOPMENT

(*c*) Mr. Albin O. Pearson, Head, Marine Environments Branch, Mail Stop 272.
(*d*) Numerical, applied research.
(*e*) A model of the circulation in a continental shelf region is being developed based on using a primitive variable formulation and numerically solving the conservation equations for mass, momentum, internal energy and salt. The hydrostatic and Boussinesq approximations are made and turbulent transfer coefficients are assumed. An empirical equation of state is used to obtain density from salinity, temperature, and pressure. The equations are solved in a finite difference form using an explicit, leap-frog technique. Methods of treating open boundaries are being studied and parametric studies will be performed to determine the effects of wind stress, bottom topography, stratification, and run-off.
(*f*) Suspended.
(*g*) A "rigid-lid" approximation has been developed to filter external gravity waves. This has produced a significant increase in the time step of the computations.
(*h*) **An Integrated Approach to the Study of Pollution Transport and Waves in the Coastal Zone–Part II–Modeling,** G. R. Young, C. H. Whitlock, T. H. Rees, J. T. Suttles, R. E. Turner, presented *IEEE Intl. Conf. Engrg. in the Ocean Environment*, Halifax, Nova Scotia, Canada, Aug. 21-23, 1974.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, LEWIS RESEARCH CENTER, Cleveland, Ohio 44135. Warner L. Stewart, Director of Aeronautics.

326-07040-630-00

COMPENDIUM ON THE DESIGN OF TURBOPUMPS AND RELATED MACHINERY

(*c*) Cavour H. Hauser, MS 5-9, Head, Single Stage Compressor Section, Fluid System Components Division.
(*d*) Exposition of theoretical and applied research.
(*e*) Compile pertinent information on turbopumps developed by NASA, the various contract research and development programs, and in-house research. This information will be correlated, and considered in proper perspective to provide a coherent presentation of the important principles of turbomachinery design. The Compendium will be published as a NASA Special Publication.
(*g*) The Compendium is in final editing in preparation for publication.

326-09403-540-00

LIQUID JET IMPINGEMENT ON SOLID SURFACES UNDER REDUCED GRAVITY CONDITIONS

(*c*) Thomas L. Labus, Aerospace Engineer; Professor Kenneth J. DeWitt, University of Toledo.
(*d*) Numerical, experimental, applied research.
(*e*) An inviscid model was chosen to describe the flow field of an axisymmetric liquid jet impinging normally to a circular disc under reduced gravity conditions. Numerical solutions to this free-boundary problem were obtained for a number of discrete cases including those in which surface tension effects were significant. This study has applications to a fundamental understanding of liquid jet delivery, liquid transfer, baffle liquid interactions and fire extinguishment.
(*f*) Reduced and normal gravity experiments completed. Analysis including inertial and surface tension effects continuing.
(*g*) Normal gravity liquid flow patterns were observed to jump from one apparently stable flow pattern to another until a completely stable configuration was reached. The plume radius was experimentally correlated in terms of the system Weber number.
(*h*) **Liquid Jet Impingement Normal to a Disc in Zero Gravity,** T. L. Labus, *NASA TMX-73405*, 1976.

326-10705-340-55

NITROGEN EBULLITION RATES DURING SUDDEN DEPRESSURIZATION OF WATER

(*b*) The Nuclear Regulatory Commission.
(*c*) Dr. Robert J. Simoneau, Mail Stop 301-1.
(*d*) Experimental, applied research.
(*e*) In a laboratory test, the physical conditions of pressurized water in a safety system for a thermal reactor are simulated. The purpose is to determine the nature of the water flow should the safety system ever be employed in an emergency shutdown.

326-10706-700-00

AN AUTOMATED SECONDARY STANDARD FOR CALIBRATING LIQUID FLOWMETERS

(*c*) Howard F. Hobart, Aerospace Research Engineer.
(*d*) Experimental development.
(*e*) The secondary standard uses six previously calibrated turbine-type flowmeters built into two manifold systems containing automatically switched flow valves. The pair of systems is capable of covering the flow range of 0.0004 to 19 l/s with an uncertainty in volume flow rate not exceeding ± 0.25 percent over the range 0.06 to 19 l/s and not exceeding ± 0.5 percent over the range 0.0004 to 0.06 l/s.
(*f*) Completed.
(*g*) Description, performance, data collection, and data reduction are presented in *NASA TMX-71876*, *Proc. 22nd Intl. Instrumentation Symp.*, May 25-27, 1976.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, WALLOPS FLIGHT CENTER, Wallops Island, Va. 23337. Mr. Robert L. Krieger, Director.

327-10707-460-00

MICROSCALE AIR-SEA INTERACTIONS AS APPLIED TO REMOTE SENSING OF THE OCEAN

(*c*) Dr. Norden E. Huang, Directorate of Applied Science.
(*d*) Experimental and theoretical; basic and applied research: possible joint work with Johns Hopkins University for Doctoral thesis.
(*e*) A new wind, wave, and current interaction tank with several unique features has been completed at Wallops Flight Center. The test section dimensions are 18.29 m (60 ft) in length, 0.91 m (3 ft) in width, and 1.22 m (4 ft) in height and filled to a depth of 0.76 m (2.5 ft). Currents are reversible and variable up to 0.51 m/sec and wind speeds of up to 25 m/sec are available. The major measuring device consists of a laser probe for slope measurements utilizing a new concept for its receiving antenna, producing data accurate to 1° of surface slope for slopes up to 48° and a frequency response beyond 100 Hz. This new device is used in conjunction with an improved capacitance height probe and anemometry equipment to produce wind, wave, and current interaction data which is then processed to yield frequency spectra, auto- and cross-correlations, and probability densities. The processing equipment is managed and controlled by an electronic programmable system controller with computing, scaling, and plotting capabilities.
(*g*) A new laser device has been used to make direct wave-slope measurements in the capillary-gravity range. Owing to the design principles, the digital nature of the system

and the use of a laser beam as a probe, the earlier problems of intensity variations and meniscus effects were avoided. Using this new technique, wave-slope spectra both down and across the channel were obtained for different wind conditions, along with corresponding mean-square slope values. Comparisons are made with existing data. The results indicate that a quasi-equilibrium state may exist for each wind speed and that it increases in intensity with increasing wind, which may imply an asymptotic nature for the equilibrium-range coefficient $C\alpha\alpha$. From the data, two significant frictional velocities, 17.5 and 31 cm/s, respectively, are identified as critical values for different ranges of wave development. Laboratory measurements utilizing this laser probe are made also for the slopes of wind waves generated on both positive and negative currents at different values of fetch. These spectra are used to obtain the growth of the spectral components at various frequency bands for increasing wind and different values of fetch and current. The results indicate that the growth of these components is not monotonic with the frictional wind speed U_*, but rather exhibits an "overshoot" phenomena at lower values of U_*, and in addition, displays a significant effect due to current condition. The peak location and spectral intensity of the spectra also show strong influence by the current condition. This results in the rms surface slope value increasing with negative current and decreasing with positive current. The results agree qualitatively with some theoretical predictions. The potential use of the current-induced effects as a means for remote sensing of ocean current is also briefly discussed.

(*h*) **On the Variation and Growth of Wave Slope Spectra in the Capillary-Gravity Range with Increasing Wind,** S. R. Long, N. E. Huang, *J. Fluid Mechanics* **77**, pp. 209-228, 1976.

Observations of Wind-Generated Waves on Variable Current, S. R. Long, N. E. Huang, *J. Physical Oceanography* **6**, pp. 962-968, 1976.

Observations of Wind Generated Waves on Variable Current, S. R. Long, N. E. Huang, presented Spring Ann. Mtg. Amer. Geophysical Union, *Trans. Amer. Geophysical Union* **57**, 4, 267, 1976.

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A Laboratory Study of the Influence of Fetch and Current on Wave Slope Spectra, S. R. Long, N. E. Huang, presented Fall Ann. Mtg. Amer. Geophysical Union, *Trans. Amer. Geophysical Union* **56**, 12, 1004, 1975.

On the Variation and Growth of Wave Slope Spectra in the Capillary-Gravity Range with Increasing Wind, N. E. Huang, S. R. Long, presented Fall Ann. Mtg. Amer. Geophysical Union, *Trans. Amer. Geophysical Union* **56**, 12, 1005, 1975.

A Laboratory Study of the Influence of Currents on Wind Generated Waves, S. R. Long, N. E. Huang, presented Fall Mtg. Amer. Geophysical Union, *Trans. Amer. Geophysical Union* **56**, 12, 1137, 1974.

Interaction of Capillary-Gravity Waves With Nonuniform Current, S. R. Long, N. E. Huang, presented Spring Mtg. Amer. Geophysical Union, *Trans. Amer. Geophysical Union* **55**, 4, 320, 1974.

Modification of Capillary Waves by Gravity Waves, S. R. Long, N. E. Huang, presented Spring Mtg. Amer. Geophysical Union, *Trans. Amer. Geophysical Union* **54**, 4, 315, 1973.

UNITED STATES NAVAL ACADEMY, DEPARTMENT OF THE NAVY, Division of Engineering and Weapons, Annapolis, Md. 21402. Captain J. R. Wales, USN, Division Director.

328-10708-420-22

DEVELOPMENT OF PSEUDO RANDOM WAVE GENERATION TECHNIQUES

(*b*) Naval Sea Systems Command.
(*c*) Dr. Bruce Johnson, Naval Systems Engineering Department.
(*d*) Computer controlled experiments; development.
(*e*) Working with MTS corporation, the wavemaker contractor for the USNA Hydromechanics Labs, "Zero variance" pseudo random wave generation techniques are used to produce desired spectra in the towing tank which have stationary statistical properties for relatively short sample lengths.
(*g*) Desired spectra achieved within ±1db for 60 second sample. Encountered wave frequency prediction and generation technique still under development.
(*h*) Published in *Proc. 18th Amer. Towing Tank Conf.*, Aug. 1977.

328-10709-420-00

EFFECT OF OCEAN WAVES ON STRUCTURES

(*b*) Conducted for Naval Academy Research Council.
(*c*) Dr. T. H. Dawson, Department of Naval Systems Engineering.
(*d*) Theoretical project in applied research.
(*e*) Develop a better understanding of the responses of ocean structures to surface-wave loadings and their interaction with the waves.
(*g*) Approximate scaling relations have been developed and examined by comparison with special analytic solutions.
(*h*) **Scaling of Fixed Off-Shore Structures,** T. H. Dawson, *Ocean Engineering* **3**, pp. 421-427, 1976.

NAVAL CONSTRUCTION BATTALION CENTER, CIVIL ENGINEERING LABORATORY, DEPARTMENT OF THE NAVY, Port Hueneme, Calif. 93043. Officer in Charge, Code L40.

329-08498-430-22

TRANSPORTABLE BREAKWATERS

(*b*) Naval Facilities Engineering Command, Director of Navy Laboratories.
(*c*) Director, Foundation Engineering Division, Code L42.
(*d*) Experimental, theoretical, and field investigation; applied research, development.
(*e*) A continuing survey of new developments and occasional analyses of particular concepts for breakwaters are undertaken to identify and evaluate concepts having potential application in a "transportable" or "portable" breakwater.
(*g*) An extensive survey of reports and published papers was conducted and reported. Analyses of flexible blankets, tethered floats, and offset surfaces have been made.
(*h*) **The WAVEGUARD™ Offset Surfaces Floating Breakwater,** R. J. Taylor, D. B. Jones, *Civil Engrg. Lab. Tech. Memo. M-42-76-16*, 24 pages, Sept. 1976.

329-09410-430-22

DYNAMICS OF FLEXIBLE CABLES IN THE OCEAN

(*b*) Naval Facilities Engineering Command.
(*c*) Dallas Meggitt, Ocean Structures Division, Code L44.
(*d*) Theoretical, laboratory, field studies; applied research.
(*e*) Development of the capability to predict and control dynamic responses of cable/buoy arrays in the deep ocean. The research has been divided into large-displacement low-frequency dynamics, and small-amplitude high-frequency dynamics (strumming). Mathematical models have been developed and tested through laboratory experi-

ments. The models are also being validated with field experiments.

(*g*) Predictive models for the frequency, amplitude and increased drag of strumming cables have been developed and limited comparisons to at-sea measurements have been made. A study of strumming-suppression devices has been started to determine the fluid mechanic mechanisms by which these devices work. An extensive series of laboratory and at-sea experiments have provided a large data base for comparison with computer prediction of large-scale dynamic behavior of cable structures.

(*h*) **In-Line and Transverse Oscillations of a Circular Cylinder in Uniform Flow,** T. Sarpkaya, *Naval Postgraduate School Tech. Rept. NPS-59SL75071*, May 30, 1975.

Strumming Predictions for the SEACON II Experimental Mooring, R. A. Skop, O. M. Griffin, S. E. Rambert, *Offshore Tech. Conf. Paper OTC 2319*, 1977.

Strumming Suppression–An Annotated Bibliography, B. E. Hafen, D. J. Meggitt, F. C. Liu, *Civil Engrg. Lab. Tech. Note N-1456*, Oct. 1976.

The Mooring Dynamics Experiment–A Major Study of the Dynamics of Buoys in the Deep Ocean, R. G. Walden, D. G. DeBok, D. J. Meggitt, J. B. Gregory, W. A. Vachon, *Offshore Tech. Conf.*, Houston, Tex., May 2-5, 1977.

329-09411-220-22

CONTROL OF SEDIMENTATION IN NAVY HARBORS

(*b*) Naval Facilities Engineering Command.
(*c*) R. J. Malloy, Foundation Engineering Division, Code L42.
(*d*) Applied experimental research.
(*e*) Several conceptual alternatives to conventional dredging are being investigated through laboratory and field experiments, to obtain environmentally cleaner and less expensive techniques/equipment to control sedimentation in Navy harbors.
(*g*) This multi-year project began in FY75.

329-09413-600-22

HYDRAULIC FLUIDIC LEVEL CONTROL UNIT

(*b*) Director of Navy Laboratories.
(*c*) E. R. Durlak, Mechanical Systems Division, Code L63.
(*d*) Experimental, theoretical investigation; applied research, development.
(*e*) Determine the feasibility of using fluidic concepts to develop a fluidic control unit that will detect and correct angular variations in position such as those experienced by a bulldozer blade.
(*f*) Completed.
(*g*) A hydraulic fluidic proximity sensor was developed and tested. This sensor was incorporated into a control unit consisting of an invented pendulum and a fluid damping system. Initial testing has indicated the control unit capable of detecting and correcting angular variations, such as those experienced by a bulldozer grader blade. The fluidic control unit requires only an input pressure source, normally available from the hydraulic control system of the vehicle. Additional development work remains on the dynamic response of the control unit.
(*h*) **Hydraulic Fluidic Level Control Unit,** R. H. Fashbaugh, E. R. Durlak, *Civil Engrg. Lab. Tech. Note 1419*, Dec. 1975.

329-10710-870-22

VACUUM WASTEWATER TRANSFER SYSTEMS

(*b*) Naval Facilities Engineering Command.
(*c*) Director, Environmental Protection Division, Code L54.
(*d*) Experimental, theoretical and field investigation; applied research, development.
(*e*) Develop design criteria for wastewater collection/transportation systems employing a single vacuum transport main in the collection of wastewaters from multiple sources (toilets, kitchens, laundry, showers).
(*g*) The transport efficiency of a vacuum system (i.e., gallons of wastewater transferred per unit of energy input) is a function of air to water ratio. The design head for a vacuum transport system must include the total head that results from the cummulative positive sloping portions of the line, and pipe line velocity and friction heads. Vortexing has been found to produce about a 40 percent decrease in vacuum wastewater transfer rate.

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U.S. NAVAL OCEAN RESEARCH AND DEVELOPMENT ACTIVITY, Bay St. Louis, NSTL Station, Miss. 39529. Dr. Ralph Goodman, Technical Director.

330-10788-420-00

WAVE-CURRENT INTERACTION STUDIES IN A LARGE-SCALE OUTDOOR SIMULATION FACILITY

(*c*) Ming-Yang Su. Address same as above.
(*d*) Basic theoretical and experimental study.
(*e*) Investigate the influence of the steady nonuniform currents, either with or without curvature, on the wave propagation and its power spectra density. The experimental facility is an outdoor flood plain simulation facility with a dimension of 300′ wide, 4500′ long and 3′ deep. The waves with a crest length of 50′ are generated mechanically.
(*f*) In the process of design and fabrication of a wave maker and sensors/data acquisition system.

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NAVAL OCEAN SYSTEMS CENTER, Department of the Navy, San Diego, Calif. 92152.

331-07219-550-22

PROPULSOR DESIGN

(*b*) Naval Sea Systems Command.
(*c*) D. M. Nelson, Naval Ocean Systems Center, Code 6342.
(*d*) Theoretical, experimental, applied research.
(*e*) Develop advanced theoretical methods for the design of underwater propulsors to program them for high speed computers, and to apply them to the design of hardware which may be experimentally verified. Work to date has concentrated on the development of a lifting-surface design method for counter-rotating propellers operating on an axisymmetric body.
(*f*) Completed.
(*g*) The two sets of counter-rotating propellers designed in the past using the lifting-surface design method performed very close to the design specifications. Hence, the method appeared to be a very useful engineering tool which should be maintained. Consequently, the computer programs have been consolidated into an easily used design package which can be supplied to other facilities. Final documentation of the design package has been published. Three new sets of counter-rotating propellers are currently in various stages of design and fabrication. When tested, these designs will provide further checks on the accuracy of the design method.
(*h*) **Development and Application of a Lifting-Surface Design Method for Counter-Rotating Propellers,** D. M. Nelson, *NUC TP 326*, Nov. 72.

A Computer Program Package for Designing Wake-Adapted Counter-Rotating Propellers: A User's Manual, D. M. Nelson, *NUC TP 494*, Dec. 1975.

331-07221-160-20

FLOW NOISE WITH POLYMERS

(*b*) Office of Naval Research.
(*c*) J. M. Caraher, Naval Ocean Systems Center, Code 6342.
(*d*) Experimental, basic research.
(*e*) Study the effect of dissolved polymers on wall pressure fluctuations in a pipe.
(*f*) Completed.
(*g*) Measurements of the turbulent boundary layer wall pressure fluctuations of polymer-water solution concentration

of 25, 50, 100, and 200 parts per million by weight of polymer at velocities from 6.73 to 17.4 m/sec were made in a 0.1016-meter-diameter pipe. Spectral data from Polyox WSR-301 concentrations of 25 and 50 weights in parts per million (wppm) indicate increases in flow noise levels at Strouhal numbers ($\omega U/R$) of less than 4 and greater than 100. Spectral data from the higher concentrations 100 and 200 wppm indicate little attenuation at low Strouhal numbers but increasing attenuation at high frequency with concentration. The attenuation at a Strouhal number of 100 was 25 db for a concentration of 200 wppm Polyox WSR-301. These results imply that polymers can be used as a noise-reducing agent in pipe flow, if the proper concentration of polymer is chosen. Space correlation measurements indicated that the pressure-fluctuation disturbances decayed at a higher rate in a 200-wppm polymer solution than the pressure-fluctuation disturbances in water only.

(*h*) **Measurement of Turbulent Boundary Layer Noise Reduction in Pipe Flow Using Polyox WSR-301,** T. L. Lewis, J. M. Caraher, *NUC TN 1698*, June 1976.

331-09445-250-00

VELOCITY PROFILES IN DRAG-REDUCING FLOWS

(*c*) Dr. M. M. Reischman, Naval Ocean Systems Center, Code 6342.

(*d*) Experimental, basic research.

(*e*) Accurately measure the mean and fluctuating components of the stream-wise velocity of drag-reducing flows in a fully-developed, two-dimensional channel flow. The purpose was to make measurements which would be sufficient to describe the mean turbulent transport of momentum and hence the mean velocity profile, test theoretical models, and make inferences about the drag-reduction mechanism. This was accomplished by making laser Doppler anemometer measurements in a turbulent channel flow of a dilute polymer solution. Measurements were also made in water to establish the "standard" character of the channel and to establish the accuracy of the laser anemometer. The laser anemometer was operated in the individual realization mode. Velocity measurements were made using three polymers. Separan AP-273, Magnifloc 837-A, and Polyox WSR-301, and at several Reynolds numbers. The flow conditions were varied to yield drag reductions ranging from 24 percent to 40 percent. The shear stress was calculated using the slope of the velocity profile near the wall. The polymer concentration was held constant at 100 wppm.

(*f*) Completed.

(*g*) The calculation procedure for predicting mean velocity profiles in drag-reducing flows is presented. The procedure is based upon the eddy diffusivity model of Cess and it requires only pressure drop, flow rate and geometry information. The predictions show excellent agreement with experimentally measured profiles in both Newtonian and drag-reducing flows.

(*h*) **Calculation of Velocity Profiles in Drag-Reducing Flows,** W. G. Tiederman, M. M. Reischman, *ASME J. of Fluids Engrg.*, Sept. 1976.

331-09449-250-20

FRICTION-REDUCING SUSPENSIONS

(*b*) Office of Naval Research.

(*c*) Dr. J. W. Hoyt, Naval Ocean Systems Center, Code 6301.

(*d*) Experimental research.

(*e*) Fibers of asbestos, glass, and acrylic were found to greatly reduce the turbulent-flow friction of aqueous suspending fluids. Experiments show that fibers having the smallest diameter, and substantial length-to-diameter ratio gave the most friction reduction at the smallest weight concentration of fiber. Current work involves the study of the effect of these drag-reducing fibers on cavitation inception. An acoustic-cavitation inception apparatus, operating at 12.5 kHz has been used to show that fibers with high length-to-diameter ratios are effective in reducing the cavitation inception index (in the same manner as long-chain polymers). An asbestos fiber suspension required twice the acoustic energy for cavitation inception than did the suspending water alone, at a fiber concentration of 500 ppm.

(*g*) See (e).

(*h*) **Cavitation in Polymer Solutions and Fiber Suspensions,** J. W. Hoyt, *Cavitation and Polyphase Flow Forum, ASME Spring Mtg.*, June 15-17, 1977, New Haven, Conn.

331-09450-250-20

WATER JET PHOTOGRAPHY

(*b*) Office of Naval Research.

(*c*) Dr. J. W. Hoyt, Naval Ocean Systems Center, Code 6301.

(*d*) Experimental basic research.

(*e*) The effects of shape parameters on the performance of water-jet nozzles discharging in air were investigated using a camera specially adapted for jet photography. The boundary-layer developing on the exit surface of the nozzle is shown to account for the jet appearance revealed by high speed photography. Optimum nozzles seem to have the boundary-layer transition to turbulence inside the nozzle; transition outside the nozzle being accompanied by spray formation and early jet disruption. The effect of polymer additives seems to be earlier transition and a thinner turbulent boundary layer inside the nozzle which improves jet performance. Also, instabilities occurring in high Reynolds number water jets discharging in air have been made visible. These instabilities include the axisymmetric mode accompanying the transition from laminar to turbulent flow at the nozzle exit, spray formation as a culmination of the axisymmetric disturbances, and further downstream, helical disturbances which result in the entire jet assuming a helical form. The final disruption of the jet is due to amplification of the helical waves. It is further shown that the amplification of the helical disturbances is due in part to aerodynamic form drag, since jets discharging into surrounding air moving at the same speed as the jet remain relatively stable, compared with the case when the jet is discharged into stagnant air.

(*g*) See (e).

(*h*) **Mechanism of Air Entrainment in a High-Speed Water Jet,** J. W. Hoyt, J. J. Taylor, *Proc. IAHR Symp. Two-Phase Flow and Cavitation*, Grenoble, p. 329, Apr. 1976.

Turbulence Structure in a Water Jet Discharging in Air, J. W. Hoyt, J. J. Taylor, to appear *Physics of Fluids*.

Effect of Nozzle Shape and Polymer Additives on Water Jet Appearance, J. W. Hoyt, J. J. Taylor, *ASME Reprint 77-FE-16*, June 1977 ASME Mtg., New Haven, Conn.

Waves on Water Jets, J. W. Hoyt, J. J. Taylor, accepted for publication, *J. Fluid Mechanics*.

331-09451-250-22

COMPLIANT SURFACE STUDIES

(*b*) Office of Naval Research.

(*c*) Dr. M. M. Reischman, Naval Ocean Systems Center, Code 6342.

(*d*) Experimental, basic research.

(*e*) Define, characterize, and evaluate the concept of drag-reduction and noise suppression by the use of a variety of compliant surfaces. An experimental investigation of the interaction of flat plate compliant surfaces and adjacent shear flows was conducted using photographic techniques in a recirculating water tunnel at NOSC. The flat plate apparatus containing a small area for the compliant surface was constructed and placed in the center of the water tunnel flow field. The compliant surfaces were polyvinyl chloride plastisols.

(*f*) Terminated.

(*g*) A substantial amount of velocity, drag, and visual measurements have been made. Results show that the compliant surfaces interact with the adjacent flow not only on the large scale (i.e. static divergence and drag increase) but also on a scale characteristic of the near-wall turbulent flow. Several plastisol gels have been evaluated as a function of elapsed time and good reproducibility obtained indicating the formulation procedure is reliable.

254-330 O - 78 - 17

331-10771-010-00

BOUNDARY LAYER CONTROL BY SUCTION

(*b*) Naval Ocean Systems Center, Naval Sea Systems Command.
(*c*) Dr. T. G. Lang, Naval Ocean Systems Center, Code 631.
(*d*) Experimental basic and applied research.
(*e*) Tests are conducted on various 30-inch long, 2-inch diamter, sting-mounted, porous-shelled models in the NOSC water tunnel at Reynolds numbers up to 10×10^6. Also, clogging tests are conducted on porous materials in the ocean. The objective is to obtain basic information on boundary layer suction for underwater vehicles.
(*g*) Laminar flow has been maintained up to 9×10^6 Reynolds number.
(*h*) Publication in process.

331-10772-250-20

POLYMER POLYDISPERSITY

(*b*) Office of Naval Research.
(*c*) Dr. M. M. Reischman, Naval Ocean Systems Center, Code 6342.
(*d*) Experimental, basic research.
(*e*) The effects of polydispersity in drag reduction were studied by testing two narrow molecular weight distribution polystyrene samples individually and in mixtures.
(*f*) Completed.
(*g*) The results indicate that the largest molecules in the distribution determine the value of the onset point and that this value decreases with increasing molecular weight. Above the onset point the magnitude of the drag reduction effect is shown to be a complex function of both molecular weight and polydispersity.
(*h*) **The Role of Polydispersity in the Mechanism of Drag Reduction,** D. L. Hunston, M. M. Reischman, *Physics of Fluids* **18,** 12, Dec. 1975.

331-10773-010-22

ROUGHNESS/TRANSITION EXPERIMENTS

(*b*) Naval Sea Systems Command.
(*c*) Dr. M. M. Reischman, Naval Ocean Systems Center, Code 6342.
(*d*) Experimental applied research.
(*e*) The objective is to measure and evaluate the effects of surface roughness, angle of attack and thermal transients on thermally stabilized boundary layers. Analytical efforts include verification of Transition Analysis Program System (TAPS) computer code with respect to roughness simulation, and establishment of a more meaningful formula to characterize the roughness/flow interaction. Transition measurements will be made on all ellipsoid of revolution in the NOSC low-turbulence water tunnel with a laser Doppler anemometer. The basic shape is a 9:1 ellipsoid of revolution, hence giving an essentially constant pressure body. Four surface configurations are to be tested with and without heat addition at the wall. The primary diagnostic tool is a TSI Series 1090 laser Doppler anemometer. Heating of the ellipsoid is accomplished via hot water circulation within the model.
(*g*) Extensive data has been taken with a smooth, cold 9:1 ellipsoid. Results agree well with theoretical analysis by McDonnell Douglas, which included complete transition and stability calculations. Qualitative data has been obtained for a cold 9:1 ellipsoid with a 30μ inch rms finish and an extensive data set has been made on an identical body with a 120μ inch rms finish. Results thus far have confirmed the theory hence validating the model construction technique and water tunnel/hardware stability.
(*h*) **Roughness Effects on Transition on an Ellipsoid–Preliminary Results,** G. L. Donohue, M. M. Reischman, *Proc. RAND Low-Speed Transition Workshop*, Sept. 1976.

331-10774-050-20

JET CAVITATION

(*b*) Office of Naval Research.
(*c*) Dr. J. W. Hoyt, Naval Ocean Systems Center, Code 6301.
(*d*) Experimental basic research.
(*e*) Using a specially designed camera adapted for photography of water jets, a study was made of the effect of polymer additives on underwater jet cavitation. The camera provides two exposures of the same field, separated in time by an adjustable period from 10 to 100μ sec. Thus a determination of the rapidity of cavitation events can be made. In addition to providing information on the speed of cavitation event, the effect of polymer additives on the cavitation was studied. The drag-reducing additive, polyacrylamide, at a concentration of 25 parts per million, greatly decreased the cavitation inception index (i.e., it was more difficult to cause cavitation), but more interestingly from the flow visualization standpoint, greatly changed the appearance of the cavitation bubbles. Whereas the bubble appearance in pure water resembled ragged groups of small bubbles with the overall impression of sharpness and roughness, the cavitation bubbles in polymer solution are larger, rounded, and of completely different appearance. The implications of this result in industrial flow operations and cavitation noise production is being studied.
(*g*) See (e).
(*h*) **Effect of Polymer Additives on Jet Cavitation,** J. W. Hoyt, *Trans. ASME, J. Fluids Engrg.* **98,** p. 106, 1976.
Visualization of Jet Cavitation in Water and Polymer Solutions, J. W. Hoyt, J. J. Taylor, presented *Intl. Symp. Flow Visualization*, Tokyo, Oct. 1977.

U.S. NAVAL RESEARCH LABORATORY, Washington, D. C. 20375. L. M. Noel, CAPT, USN, Commander.

332-07063-020-00

DIFFUSIVITY OF HEAT AND SALINITY IN WATER

(*c*) Dr. Allen H. Schooley, Code 8304, Building 208.
(*d*) Experimental exploratory applied research.
(*e*) Molecular and eddy diffusivity of temperature and salinity in water were measured with no turbulence and controlled amounts of increasing turbulence.
(*f*) Completed.
(*g*) The dissipation of turbulent power density (P) was found to be on the order of 10^7 larger than the power density (P′) consumed in changing the thickness of the pycnocline. The experiments hint that P/P′ may be relatively constant over a range of turbulence.
(*h*) **Turbulent Diffusion of Temperature and Salinity: An Experimental Study,** A. H. Schooley, *8th Symp. Naval Hydrodynamics*, ONR, Cal. Tech., Aug. 1970. *Symp. Proc. ARC-179*, Office of Naval Research, Arlington, Va.

332-07064-460-00

VISCOUS FLOW IN THE AIR AND WATER WITHIN THE MOLECULAR SUBLAYERS AT THE NAVIFACE (SEA-AIR INTERFACE)

(*c*) Dr. Allen H. Schooley, Code 8304, Building 208.
(*d*) Phenomenological applied research.
(*e*) Heat balance at the sea surface is assumed to be dominated by molecular evaporation, and molecular heat conduction very near to the undulating naviface, plus a radiation balance term. The effective thickness of the molecular layers is dependent on the conditions of wind speed, phase position along the wave, air-sea temperatures, and cloud conditions. Laboratory wind-tunnel experiments are being used to help understand limited observations at sea.
(*f*) Completed.
(*g*) Some preliminary results are given under (h).
(*h*) **Diffusion Sublayer Thickness Over Wind Disturbed Water Surfaces,** A. H. Schooley, *J. Phys. Oceanog.* **1,** 3, p. 221, July 1971.
Whitecap Suppression by Cloud Shadows, A. H. Schooley, *J. Mar. Res.* **30,** 3, p. 315, Sept. 1972.

Wind-Swept Water Surface in Laboratory Cooled by Applying Heat, A. H. Schooley, *J. Mar. Res.* **31,** 1, p. 93, Jan. 1973.

332-07065-420-22

MICROWAVE SCATTERING FROM WIND WAVES

(*b*) Department of the Navy.
(*c*) Dr. John W. Wright, Code 8344.
(*d*) Basic experimental research on wind-generated water waves using microwave radars; basic theoretical research on mechanisms for the growth of water waves by the wind.
(*e*) Understand the short gravity-capillary part of the oceanic water wave system. Microwave radars are used to measure water wave speeds and amplitudes in laboratory wave tanks. Emphasis is placed on the response of the spectrum to external forces and other parts of the wave spectrum. Theory of wave-wave interactions and how the wind generates waves is conducted.
(*g*) The temporal growth of waves having wavelengths between 7 mm and 7 cm has been measured over a wide range of windspeeds. Effects of straining due to long water waves on the short gravity-capillary part of the wave spectrum have been studied both experimentally and theoretically; good agreement exists for wind speeds less than ten knots.
(*h*) **Wind-Generated Gravity-Capillary Waves; Laboratory Measurements of Tempord Growth Using Microwave Sachscatter,** T. R. Larson, J. W. Wright, *J. Fluid Mech.* **70,** pp. 417-436, Aug. 1975.
Microwave Scattering and the Straining of Winds Generated Waves, W. C. Heller, J. W. Wright, Rad SC **10,** pp. 139-147, Feb. 1975.
The Wind-Drift and Wavebreaking, J. W. Wright, *J. Phys. Oceanog.* **6,** pp. 402-405.
Growth of Gravity-Capillary Waves in a Coupled Shear Flow, G. R. Valenzuela, *J. Fluid Mech.* **76,** pp. 229-250, Aug. 1976.
Growth of Waves by Modulated Wind Stress, G. R. Valenzuela, J. W. Wright, *J. Geophys Res.* **81,** pp. 5795-5796, Nov. 1976.
On the Highest and Other Solitary Waves, J. Witting, *SIAM Journal of Applied Math.* **28,** pp. 700-719, 1975.
Turbulent Structure in Benthic Boundary Layers, *Book, Bottom Turbulence,* J. C. J. Nihoul, ed., Elsevier Science Publishing Co., Amsterdam, pp. 59-81, 1977.

332-07067-420-00

SEA SPECTRA ANALYSIS

(*c*) Denzil Stilwell, Jr. and R. O. Pilon, Code 7914.
(*d*) Experimental and theoretical investigations of optical techniques for the measurement of statistical descriptors of the ocean surface.
(*e*) This program involves Sea Photo Analysis (SPA) techniques wherein the two-dimensional spectrum of the ocean surface is obtained by coherent Fourier analysis of transparencies exposed under a specified set of conditions. These procedures have been verified by simultaneous photographic and in situ measurements. Computer models of the reflected and upwelling polarized radiances of the ocean surface have been developed.
(*g*) SPA techniques have been used to provide detailed ground truth for radar, laser and acoustic scattering.
(*h*) **Determination of Ocean Surface Descriptors Using Sea Photo Analysis Techniques,** R. O. Pilon, *NRL Rept. 7574,* July 1973.
Directional Spectra of Surface Waves from Photographs, D. Stilwell, Jr., R. O. Pilon, *J. Geophys. Res.* **79.** 9, pp. 1277-1284, Mar. 1974.

332-08523-250-20

DRAG REDUCTION

(*b*) Office of Naval Research and Naval Ship Systems Command.
(*c*) R. C. Little, Code 6170.
(*d*) Experimental and theoretical applied research.
(*e*) Combined experimental and theoretical investigations were made of the drag reducing ability of polymers and association colloids in both aqueous and nonaqueous environments. An improved understanding of the mechanism of drag reduction will allow the synthesis of even more effective agents for both Naval and civilian applications. The ultimate objective of the project was to relate the observed drag reduction effect to the molecular and micellar structure of the agents used.
(*f*) Suspended.
(*h*) **Some Observations on Drag Reduction in Polyacrylic Acid Solutions,** O. K. Kim, R. C. Little, R. Y. Ting, accepted for publication in *Intl. Symp. Polyelectrolytes and Their Applications,* A. Rembaum, E. Selegny, eds., Reidel Pub. Co., Dordrecht, Holland, p. 275, 1975.
Drag Reduction: Polymer Homology, Solvent Effects and Proposed Mechanisms, published in *Polymeres et Lubrification, Editions due Centre National de la Recherche Scientifique,* Paris, R. C. Little, R. J. Hansen, D. L. Hunston, O. K. Kim, R. L. Patterson, R. Y. Ting, 1975.
Drag Reduction Characteristics of Poly(acrylamides) in Aqueous Magnesium Sulfate and Acetone Solutions, R. L. Patterson, D. L. Hunston, R. Y. Ting, and R. C. Little, *J. Chem. Eng. Data* **20,** 381 (1975).
Potassium Polyphosphate and Its Drag Reducing Properties, D. L. Hunston, R. C. Little (submitted to *1977 BHRA Conference on Drag Reduction,* England).
The Interaction of Sodium Dodecyl Sulfate and Polyethylene Oxide, R. L. Patterson, R. C. Little, *Nature* **253,** No. 5486 (1975).
Some Observations on the Zinc Stearate-Toulene System R. C. Little, *J. Colloid and Interface Sci.* **51,** 200 (1975).
The Drag Reduction of Poly(ethylene oxide)-Carboxylate Soap Mixtures, R. L. Patterson, R. C. Little, *J. Colloid and Interface Sci.* **53,** 110 (1975).
Number-Average and Viscosity-Average Molecular Weights of Popular Drag Reducing Polymers, R. C. Little, R. Y. Ting, *J. Chem. Eng. Data* **21,** 422 (1976).
The Drag Reduction Phenomenon: Observed Characteristics, Improved Agents and Proposed Mechanisms, R. C. Little, et al., *I & EC Fund.* **14,** 283 (1975).
Characterization of the Drag Reducing Properties of Poly(ethyleneoxide) and Poly(acrylamide) Solutions in External Flows, R. C. Little, R. L. Patterson, R. Y. Ting, *J. Chem. & Eng. Data* **21,** 281 (1976).
Breaking Emulsions in Navy Bilge Collection and Treatment Systems, R. C. Little, R. L. Patterson (submitted to *Environmental Science and Technology*).
Breaking Emulsions in Navy Bilge Collection and Treatment Systems, R. C. Little, R. L. Patterson, *NRL Memo Rept. 3424,* Nov. 1976.

332-08524-250-00

STABILITY OF LAMINAR PIPE FLOWS OF DRAG-REDUCING POLYMER SOLUTIONS

(*c*) R. J. Hansen.
(*d*) Experimental basic research.
(*e*) Experimental work is conducted to ascertain the nature of the transition from laminar to turbulent flow in pipe flows where, by virtue of small pipe diameter or large solvent viscosity, large shear rates are realized at subcritical Reynolds numbers. Experimental techniques employed include pressure drop measurements and laser Doppler anemometry.
(*f*) Completed.
(*g*) Laser Doppler anemometry is employed to measure the mean velocity and turbulence intensity in the early turbulence regime of the flow of a dilute polymer solution through a small-diameter tube. (This regime is initiated at an onset Reynolds number in the subcritical range, above which the polymer additive increases drag, and continues through the transitional Reynolds number range, where a continuous transition to turbulent flow with reduced drag

is observed.) When the onset flow rate for early turbulence is exceeded, the mean velocity profile becomes progressively flatter with increasing flow rate. That is, a gradual transition from a laminar profile at onset to a more "turbulent-like" profile takes place. Turbulence intensities at the tube centerline are about one half those of a fully-developed turbulent flow. The inference is drawn from these results that the onset of early turbulence corresponds to the flow becoming hydrodynamically unstable due to viscoelastic effects introduced by the polymer additive and that the character of the flow is intermediate between laminar and fully developed turbulent flow.

(*h*) **Laser Doppler Velocimetry Studies of Early Turbulence,** J. L. Zakin, C. C. Ni, R. J. Hansen, M. M. Reischman, *Physics of Fluids*, 1977.

332-09418-010-22

TURBULENT STRUCTURE OF GEOPHYSICAL BOUNDARY LAYERS

(*b*) Department of the Navy.
(*c*) Mr. Clifford Gordon, Code 8342.
(*d*) Field studies of the benthic boundary layer in an estuary including measurements of Reynolds stress, turbulent kinetic energy and velocity profiles.
(*e*) Establish whether the findings of contemporary wind tunnel and laboratory boundary layer investigations are directly applicable to the large scale turbulent structure of geophysical boundary layers. The most specific interest is in the scaling behavior of the bursting phenomenon.
(*g*) Direct measurements have shown that most of the vertical transport of horizontal momentum in a marine boundary layer occurs intermittently; 90 percent of the transport takes place in about 30 percent of the time.
(*h*) **A Pivoted-Vane Current Meter,** C. M. Gordon, C. F. Dohne, *Ocean* **73,** pp. 46-49, IEEE, Inc., N. Y., 1973.
Some Observations of Turbulent Flow in a Tidal Estuary, C. M. Gordon, C. F. Dohne, *J. Geophys. Res.* **78,** pp. 1971-1978, Apr. 20, 1973.
Intermittent Momentum Transport in a Geophysical Boundary Layer, C. M. Gordon, *Nature* **248,** pp. 392-394, Mar. 29, 1974.
The Period Between Bursts at High Reynolds Number, C. M. Gordon, *Phys. Fluids*, Feb. 1975.

332-09419-030-22

VORTEX-INDUCED VIBRATION OF UNDERSEA CABLES

(*b*) Naval Facilities Engineering Command.
(*c*) Owen M. Griffin, Steven E. Ramberg, Code 8441.
(*d*) Applied experimental and theoretical aesearch.
(*e*) The vortex-excited motions of marine cables are studied experimentally and theoretically. Of particular interest is the development of practical methods to predict the vibration response and increased drag of strumming cables.
(*g*) A heuristic model has been developed that can predict the maximum modal response provided that the modal frequencies, damping, and in-water added mass are known. Laboratory experiments have obtained the required modal information over a wide range of conditions including taut and slack cables. The methodology, along with increased drag predictions, has been verified by comparison to the measured Seacon II cable array motions.
(*h*) **The Resonant Vortex-Excited Vibrations of Structures and Cable Systems,** O. M. Griffin, R. A. Skop, S. E. Ramberg, *Offshore Tech. Conf. Paper 2319* (May 1975).
Some Resonant Vibration Properties of Marine Cables with Application to the Prediction of Vortex-Induced Structural Vibrations, S. E. Ramberg, O. M. Griffin, R. A. Skop, *ASME Ocean Engrg. Mechanics, OED* **1,** pp. 29-42 (1975).
Free Vibrations of Taut and Slack Marine Cables, S. E. Ramberg, O. M. Griffin, *ASCE J. Structural Div*, 1977.
Strumming Predictions for the Seacon II Experimental Mooring, R. A. Skop, O. M. Griffin, S. E. Ramberg, *Offshore Tech. Conf. Paper 2884* (May 1977).

332-09420-250-00

INTERACTION OF A SHEAR FLOW WITH A COMPLIANT BOUNDARY

(*b*) Office of Naval Research.
(*c*) R. J. Hansen.
(*d*) Experimental and theoretical basic research.
(*e*) The effects of surface compliance on boundary layer flows is examined experimentally and theoretically. Of particular interest are alterations in skin friction drag due to surface compliance and deformations in the surface caused by the fluid.
(*g*) An experimental study of the flow over a compliant region of a flat plate has been completed. Three major classes of surface waves generated by the flow are identified in terms of their origin and propagation velocities. The nondimensional onset velocity for two of the three types of waves is identical to that previously observed in rotating disk experiments. The third type of wave, associated with irregularities in the coating topography, has a lower onset velocity. A high-aspect-ratio rectangular channel has been constructed to conduct detailed studies of the effects of various types of flexible surfaces on skin friction drag.
(*h*) **Further Observations on Flow Generated Surface Waves in Compliant Surfaces,** R. J. Hansen, D. L. Hunston, *J. Sound and Vibration* **46,** pp. 593-596 (1976).

332-10711-030-20

FLOW-INDUCED MOTIONS OF FLEXIBLE CABLES AND CYLINDERS ALIGNED WITH THE MEAN FLOW DIRECTION

(*b*) Office of Naval Research.
(*c*) C. C. Ni and R. J. Hansen, Code 8441, Bldg. 3-4.
(*d*) Basic and applied experimental research.
(*e*) A large, blowdown water channel with a 14.8 m long, 19 cm i.d. transparent test section is used in this work. Flow velocities in the test section of up to 9 m/sec can be realized. A rigid rod of the same diameter as the flexible test specimen is mounted on the axis of the test section for the first twenty hydraulic diameters to produce a fully developed annular flow. The front end of the test specimen is attached to the downstream end of this rod, and the downstream extremity of the test piece may be either free to move or fixed. The lateral, flow-induced motions of the flexible cable or cylinder are monitored optically.
(*g*) Flow-induced lateral motions on the order of one cylinder diameter in amplitude are observed in 1.6 cm diameter flexible cables and cylinders. The motions can be described as a limited band stationary, random process of predominantly low frequency content (under 20 Hz). Above a critical flow velocity a stationary bending deformation (static divergence) is superimposed on the random disturbances of a smooth cylinder with a free downstream end.
(*h*) **An Experimental Study of Flow-Induced Motions of Flexible Cables and Cylinders Aligned with the Mean Flow Direction,** *ASME Paper 76-WA/FE-15* 1976.

DAVID W. TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER, Department of the Navy, Headquarters, Bethesda, Md. 20084.

ANNAPOLIS LABORATORY, Annapolis, Md. 21402. L. F. Marcous, Head, Propulsion and Auxiliary Systems Department; R. J. Wolfe, Head, Materials Department.

333-10712-550-22

WATERJET PROPULSION STUDIES

(*b*) Naval Sea Systems Command.
(*c*) J. Stricker, Gas Turbines Branch (Code 2721).
(*d*) Theoretical and experimental; applied research and development.

(*e*) Waterjet systems and components are being studied for high performance planing craft, hydrofoils, and surface effect ships. System concepts aimed toward improving performance and reducing machinery weight have been devised and analyzed, and promise of achieving gains in these areas shown for the following items: (1) use of boundary layer-ingesting inlet designs for planing craft; (2) use of thrust augmentation devices for hydrofoil operation at low speeds; and (3) use of series-installed pumps and nozzles in surface effect ships. Design of axial flow and centrifugal pumps has been studied to identify possible improvements in efficiency and weight. Effects of polymer injection have been analyzed and scale model pump experiments run. Experimental studies of fixed and variable area pod-type inlets have been made, and analytical studies in this area are underway. Model studies of flush inlets for planing hulls are currently underway, with emphasis on inlet-hull interaction and inlet added-drag characteristics.

(*g*) Analyses of medium and high speed hydrofoil designs show promise for take-off thrust augmentation systems in improving range and/or payload capabilities. Auxiliary fan jet thrusters are the most likely candidates for this requirement. Series-installed pumps with diverter valves show promise of improving the part-power or cruise-condition range of high speed SES's, and also in improving the efficiency of large planing craft waterjet systems which are required to operate at medium-speed cruise and high-speed dash conditions. The effects of boundary layer flow ingestion on planing craft efficiencies and total thrust requirements are currently being investigated, and model test results are inconclusive at this time. Available design methods for high speed strut-pod inlet systems have been shown experimentally to be inadequate and current efforts are aimed at developing accurate design procedures.

(*h*) DTNSRDC reports may be requested through NTIS:
Experimental Facility for Strut-Pod Inlets, *No. SPD 671-01*, Dec. 1975.
Performance Gains of Wide Boundary Layer Inlet Systems, *No. PAS-75-45*, Mar. 1976.
Hydrodynamic Performance of a Variable Area Hydrofoil Inlet, *No. SPD-735-01*, Feb. 1977.

333-10713-520-22

MATERIALS FOR HIGH PERFORMANCE SHIPS

(*b*) Naval Material Command, Support Technology Division (NAVMAT 034).
(*c*) A. Rufolo, Code 284 and J. J. Kelly, Code 2803.
(*d*) Experimental; applied research and development.
(*e*) Development of coatings and overlay materials which can provide corrosion, erosion and antifouling protection; of structural materials which can resist erosion, primarily that produced by cavitation; of fabric reinforced rubber for seals and skirts of surface effect ships (SES) and surface effect vehicles (SEV). Cavitation studies are performed on (1) a rotating disk apparatus, (2) vibratory equipment, and (3) a high speed Venturi nozzle. Dynamic performance studies on fabric reinforced rubber are carried out on a rotating drum impactor. Field trials have included experimental applications on Navy hydrofoils and air-cushion vehicles (ACV).
(*g*) Materials with high resistance to cavitation erosion have been evaluated and catalogued. Skirt/seal operational life, demonstrated to be a critical problem, has been increased through the discriminating selection of the components of fabric-reinforced rubbers. Basic studies continue on the dynamic behavior of skirt/seal materials.
(*h*) **Development and Evaluation of Skirt/Seal Materials for Surface Effect Vehicles,** J. J. Kelly, W. Klemens, H. S. Preiser, DTNSRDC, Annapolis, Md., in *Hovering Craft A Hydrofoil*, Kalerghi Publications, U.K., Sept. 1976.

333-10714-610-22

FIRE-RESISTANT HYDRAULIC FLUIDS FOR NAVAL SURFACE SHIPS

(*b*) Naval Sea Systems Command (NAVSEA 035).
(*c*) R. W. McQuaid, Code 2831.
(*d*) Experimental; research and development.
(*e*) Development of substitute fire-resistant hydraulic fluids to replace the currently used phosphate ester MIL-H-19457B for surface ship hydraulic systems, including elevator systems of aircraft carriers, ram tension and sliding block systems of underway replenishment supply ships. The requirements for the new hydraulic fluids are: increased fire-resistance, thermal and oxidative stability, better load-carrying capability, higher viscosity index, improved compatibility with system materials, and environmental acceptability. Potential candidates as suitable replacement fluids are water-base, silicone and phosphazene type fluids. Military specification MIL-H-22072 water-glycol fluid has been found adequate as an interim substitute for MIL-H-19757B. It gave satisfactory performance in laboratory tests of two weapons elevator pumps for approximately 1000 hours. It is currently being evaluated in pumps of lower fluid capacity. Longer term objectives of this program are to develop a water-based hydraulic fluid with superior properties to those of MIL-H-22072, particularly in the area of higher flash point residue, improved seawater compatibility and better thermal characteristics.

333-10715-610-22

SEAWATER EMULSIFIABLE HYDRAULIC FLUIDS FOR SUBMARINES

(*b*) Naval Sea Systems Command, NAVSEA 035.
(*c*) C. L. Brown, Code 2831.
(*d*) Experimental; research and development.
(*e*) Seawater and contamination of submarine external hydraulic systems is a continual problem for the U.S. Navy. The currently used petroleum-based fluid (MS 2110TH, MIL-L-17672) does not provide adequate corrosion protection for the degree of seawater contamination and the static conditions which the system sometimes experiences. A new type of hydraulic fluid, meeting the military specifications MIL-H-24430A has been developed and field tested in four submarines for approximately one year. During this test period the hydraulic systems experienced seawater contamination of up to 4.2 percent; there was no significant change in the fluid properties resulting from this amount of seawater contamination, and the overall performance of the fluid was considered satisfactory. Laboratory analysis of the experimental fluid samples revealed unusually high concentration of insoluble particulate matter, which was identified as a very tight emulsion of reaction products of an emulsifying additive. However, no observable adverse effects, such as filter clogging or valve sticking, were reported during the test period. The insoluble particles were for the most part smaller than 14 micrometers, thus they were not trapped by the shipboard filter elements which have absolute porosities of 25 micrometers or larger.
(*f*) Service use of fluid awaits resolution of the significance of particulates.

DAVID W. TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER, Department of the Navy, Headquarters, Bethesda, Md. 20084.

CARDEROCK LABORATORY, Bethesda, Md. 20084. W. E. Cummins, Head, Ship Performance Department.

334-08529-040-22

TWO-DIMENSIONAL ADDED-MASS AND DAMPING FOR BODIES OSCILLATING IN A FLUID OF FINITE DEPTH

(*b*) Naval Ship Systems Command.
(*c*) Mr. D. J. Sheridan, Ship Performance Department.
(*d*) Theoretical; applied research.
(*e*) A method for predicting the two-dimensional added-mass and wave damping for arbitrary bodies was developed for shallow water flows using a closefit source distribution technique.
(*f*) Completed.

(*g*) The potential function for a single source oscillating in a fluid of finite depth has been developed.

(*h*) **Computation of the Velocity Potential for a Pulsating Source in a Fluid with Free Surface and Finite Depth,** D. J. Sheridan, *DTNSRDC Rept. SPD-652-01*, Dec. 1975.

334-08531-550-22

CONTRAROTATING PROPELLERS

(*b*) Naval Sea Systems Command.

(*c*) E. B. Caster, Mathematician, Propulsor Technology Branch.

(*d*) Theoretical; development.

(*e*) To apply recent advances in propeller design-theory and numerical computation procedures to the design of contrarotating propellers and thus permit improvements in the propeller operational characteristics including cavitation performance and vibration characteristics.

(*f*) Theoretical work completed; experimental phase awaiting funds.

(*g*) A computer program for the preliminary design of single screw propellers, based on Lerbs moderately loaded propeller theory, was recently developed to run on the CDC high speed computer. A similar new propeller design program has also been developed for contrarotating propellers. The most important new feature of the contrarotating propeller design procedure was to use Kerwin's field point velocity program based on finite bladed lifting surface theory to determine the interaction effects of the forward and aft propellers. The new and old contrarotating propeller design programs gave similar results for the forward propeller but significantly different results were obtained for the aft propeller. The new design computer program should give designers a better tool for designing and predicting the performance of contrarotating propellers.

(*h*) **A Lifting Line Computer Program for the Preliminary Design of Propellers,** E. B. Caster, et al., *DTNSRDC Rept. SPD-595-01*, Sept. 1976.
A Computer Program for the Preliminary Design of Contrarotating Propellers, E. B. Caster, et al., *DTNSRDC Rept. SPD-596-01*, Sept. 1976.

334-08533-550-22

BLADE TURNING EFFORT OF CONTROLLABLE PITCH PROPELLERS

(*b*) Naval Sea Systems Command.

(*c*) Robert J. Boswell.

(*d*) Experimental; development.

(*e*) Provide data applicable to the prediction of blade turning effort and blade spindle strength requirements of controllable-pitch (CP) propellers. This information is necessary in order to improve the design technology and structural reliability of CP propellers.

(*f*) Completed.

(*g*) The results of this project showed the effects of blade width, pitch, advance coefficient, rake, and skew on blade turning effort, as discussed in the report listed in paragraph (h).

(*h*) **Experimental Spindle Torque and Open-Water Performance of Two Skewed Controllable-Pitch Propellers,** R. J. Boswell, et al., *DTNSRDC Rept. 4753*, Dec. 1975 (available Defense Documentation Center).

334-08540-250-00

POLYMER DRAG REDUCTION AND DEGRADATION STUDIES

(*c*) Dr. T. T. Huang, Hydrodynamics Branch.

(*d*) Experimental and theoretical work; basic research.

(*e*) Experimental characterization of polymer drag-reduction by pipe flow tests and shear degradation in rotating disk tests. Use of data to develop reliable drag-reduction prediction techniques for plates and bodies.

(*f*) Completed.

(*g*) Gross characterization of polymer drag reduction and degradation have been completed.

(*h*) **Drag Reduction and Shear Degradation of Dilute Polymer Solutions as Measured by a Rotating Disk,** T. T. Huang, N. Santelli, *DTNSRDC Rept. 3678*, Sept. 1972.
Drag Reduction of Degraded and Blended Polymer Solutions, T. T. Huang, N. Santelli, *DTNSRDC Rept. 4096*, Dec. 1975.

334-08542-520-00

SHIP RESISTANCE COMPONENTS

(*c*) Dr. T. T. Huang, Hydrodynamics Branch.

(*d*) Experimental work primarily; applied research.

(*e*) Shear stress pressure distribution, wake velocity, streamlines, and waves are being measured for a Series 60/Block 60 surface ship model. The directionality of shear stress is determined from high aspect ratio hot films. The data will serve as a base for development and verification of resistance prediction techniques. Forces and free-surface elevations of a yawed surface-piercing plate are also investigated.

(*g*) Measurements of force and free-surface elevations for a yawed surface-piercing plate have been completed.

(*h*) **Experimental Forces and Free-Surface Elevations for a Yawed Surface-Piercing Plate,** R. B. Chapman, *DTNSRDC Rept. 76-0002*, Jan. 1977.

334-09430-550-00

WATERJET PUMP DEVELOPMENT FOR SHIP PROPULSION

(*c*) R. S. Alder.

(*d*) Theoretical and experimental; applied research.

(*e*) To incorporate current available theoretical procedures for the design of conventional and supercavitating propellers into the design of a waterjet impeller/stator system in order to improve pump efficiency and/or impeller cavitation performance and the overall efficiency of waterjet systems. Waterjet propulsor systems fulfill specialized power requirements where appendage and draft restrictions are critical to maneuverability and overall performance of the ship.

(*f*) Discontinued.

(*g*) Performance tests have been completed on a 31-ft waterjet-powered planing craft equipped with a redesigned impeller. Inlet velocity measurements were also obtained in the experiments. Experimental results are presently being analyzed. Further waterjet testing is planned using a static test stand.

(*h*) **Inlet Velocity Distribution of a Full Scale Flush Inlet Waterjet,** R. S. Alder, *DTNSRDC Rept. SPD-718-01*, Aug. 1976.

334-09431-550-22

BLADE LOADING OF CONTROLLABLE PITCH PROPELLERS

(*b*) Naval Sea Systems Command.

(*c*) Robert J. Boswell, Code 1544.

(*d*) Experimental; development.

(*e*) A combined experimental and analytical program is underway to develop improved techniques for predicting blade loading of controllable-pitch propellers over a complete range of operating conditions. This is necessary in order to improve the design technology and structural reliability of controllable pitch propellers. The six components of blade loading were measured behind a single screw hull and behind a twin screw hull under the following simulated conditions: steady ahead, crash astern (deceleration), crash ahead (acceleration), and ship motions. Dependent upon the conditions simulated, the time average, transient, and unsteady portions of each component of blade loading were determined. Additional experiments under idealized flow conditions will be conducted during FY77 in an attempt to isolate the reasons for discrepancy between theory and experiments as described in paragraph (g).

(*g*) The experimental results behind the model hulls showed that hull pitching substantially increases the unsteady loading, and that unsteady loading during simulated crash ahead and crash astern operation was smaller than the unsteady loading for full power steady ahead operation. For steady ahead operation, circumferential variation of loading determined from the model experiments agreed fairly well with full-scale data, but was substantially larger than the theoretically calculated values.

(*h*) **Experimental Determination of Mean and Unsteady Loads on a Model CP Propeller Blade for Various Simulated Modes of Ship Operation,** R. J. Boswell, et al., presented *11th ONR Symp. Naval Hydrodynamics*, University College London, London, England, Apr. 1976. (Available Supt. of Documents, U.S. Government Printing Office, Washington, D.C. 20402).
Experimental Unsteady and Mean Loads on a CP Propeller Blade on a Model of the FF1088 for Simulated Modes of Operation, *DTNSRDC Rept. 76-0125*, Oct. 1976 (available from Defense Documentation Center).

334-09432-550-22

PROPELLER BLADE PRESSURE DISTRIBUTION

(*b*) Naval Sea Systems Command.
(*c*) Robert J. Boswell, Code 1544.
(*d*) Experimental; development.
(*e*) Provide experimental measurements of the pressure distribution on models of controllable pitch (CP) propellers. Measurements will be made with the propellers operating in uniform flow and in nonuniform flow for design conditions and for off-design conditions including backing, crash back and crash ahead operations. This information is required in order to evaluate the theoretical methods being developed for predicting the hydrodynamic performance of propellers, and in order to improve the design technology and structural reliability of CP propellers. During FY77 the pressure is being measured at 40 locations on one CP propeller in uniform flow and in inclined flow.
(*g*) Results of preliminary experiments indicate that the experimental technique is promising.

334-09434-550-00

PROPELLER DESIGN THEORY FOR HIGHLY SKEWED PROPELLERS

(*c*) Dr. T. Brockett, Hydrodynamics Branch.
(*d*) Theoretical; applied research.
(*e*) Numerical analysis and computer program are being developed for an analytical formulation of the propeller design problem which includes the effect of the radial component of the blade-surface normal vector. Propellers with large variations in warp (or skew) angle, rake, or pitch can have a significant radial component. Unless the effect of this radial component is properly accounted for, uniformly satisfactory cavitation and powering performance is not likely to be achieved.
(*f*) Completed.
(*g*) Computer program suitable for routine propeller design operations. Example propeller designed and manufactured. Experimental evaluation showed improved cavitation and propulsion performance relative to alternative design schemes.
(*h*) **LFTSUR–A Lifting-Surface Propeller-Design Program,** J. H. McMahon, *DTNSRDC Rept. SPD-731-01*, Oct. 1976.
Cavitation Characteristics and Comparison of Model Propellers 4620 and 4673, G. S. Belt, *DTNSRDC Rept. SPD-731-02*, Oct. 1976.

334-09436-550-00

TANDEM PROPELLER DESIGN

(*b*) Naval Sea Systems Command.
(*c*) Robert J. Boswell.
(*d*) Theoretical; experimental, design.
(*e*) A procedure has been developed for the design of tandem propellers. The specific tandem propeller arrangement considered is two propellers operating one behind the other, on the same shaft with the same rotational speed and direction of rotation. The procedure has been proven valid for the design of tandem units operating in uniform inflow and should be applicable to wake-adapted design cases. The ability to design tandem propeller units which meet prescribed performance criteria and which operate at acceptable propeller efficiencies could have considerable impact on ship powering technology. Tandem propellers can be applied to ships with high delivered horsepower, where vibration and cavitation erosion are anticipated problems, and where the physical constraints make a tandem arrangement attractive.
(*f*) Completed.
(*g*) A tandem propeller unit designed using this method was constructed and evaluated for open-water propulsion and cavitation performance. The performance data showed that the unit produced the desired thrust at the design revolution rate and that the open-water efficiency was as good as a single propeller carrying the same load at the same operating conditions. Cavitation performance was comparable to an equivalent single propeller, but the cavitation on the aft propeller was somewhat dependent on clearance between the propellers.
(*h*) **Cavitation and Open-Water Performance of a Set of Tandem Propellers,** R. D. Kader, *DTNSRDC Rept. SPD-592-01*, Nov. 1974.
A Procedure for the Design of Tandem Propellers, S. B. Denny, *DTNSRDC Rept. 530-H-04*, June 1974.

334-09437-010-00

STRUCTURE OF BOUNDARY LAYERS AND TURBULENCE WITH APPLICATION TO DRAG REDUCTION, NOISE GENERATION, AND WAKE DETECTION

(*c*) Dr. T. T. Huang, Hydrodynamics Branch.
(*d*) Experimental work, basic research.
(*e*) Measure the structure of hydrodynamic turbulence by hot-film anenometers and Laser Doppler Velocimeter (LDV) in boundary layers, wakes, and jets, with emphasis on data relevant to drag reduction, transition, noise generation, cavitation, wake detection and diffusion.
(*g*) Hot-film measurements and detailed computation of the structure of high Reynolds number turbulence behind a grid in a water tunnel have been completed. Hot-wire measurements of turbulence structure on thick axisymmetric boundary layer. Pressure fluctuation in the regions of flow transition have been measured. Analytical investigation of the influence of viscous effects on a model/full-scale cavitation scaling has been made. Hot-wire measurements of turbulence structure on thick axisymmetric boundary layer have been completed.
(*h*) **Pressure Fluctuations in the Regions of Flow Transition,** T. T. Huang, D. E. Hannan, *DTNSRDC Rept. 4723*, Dec. 1975.
Influence of Viscous Effects on Model/Full-Scale Cavitation Scaling, T. T. Huang, F. B. Peterson, *J. Ship Research* **20**, 4, pp. 215-223, Dec. 1976.
Pressure Fluctuations in the Transition Regions of Forebodies of Revolution, T. T. Huang, presented *Low-Speed Boundary-Layer Transition Workshop: II*, Santa Monica, Calif., 13-15 Sept. 1976 (RAND Corporation).
Grid Turbulence in Air and Water, F. Frenkiel, P. Klebanoff, T. T. Huang, presented *Amer. Physical Society*, College Park, Md., Nov. 1975.

334-09438-010-00

LAMINAR FLOW BODIES

(*c*) P. S. Granville, K. P. Kerney, Naval Hydromechanics Division.
(*d*) Theoretical; applied research.
(*e*) Analytical methods are being devised to predict viscous drag of bodies of revolution with maximum laminar boundary layer and hence, minimum drag.
(*g*) See (h).
(*h*) **Geometrical Characteristics of Streamlined Shapes,** P. S. Granville, *J. Ship Research* **13**, 4, Dec. 1969.
The Prediction of Transition from Laminar to Turbulent Flow in Boundary Layers on Bodies of Revolution, *10th*

Symp. Naval Hydrodynamics, June 1974, Office of Naval Research, Arlington, Va.
Similarity-Law Entrainment Method for Thick Axisymmetric Turbulent Boundary Layers in Pressure Gradients, P. S. Granville, *DTNSRDC Rept. 4525*, Dec. 1975.
Description and Evaluation of a Digital-Computer Program for Calculating the Viscous Drag of Bodies of Revolution, K. P. Kerney, N. M. White, *DTNSRDC Rept. 4641*, Dec. 1975.

334-09439-520-00

VISCOUS DRAG OF SURFACE SHIPS

(*c*) P. S. Granville, Naval Hydromechanics Division.
(*d*) Theoretical; applied research.
(*e*) Analytical method is developed for predicting the partial form factor of the viscous drag of surface ships which is required in extrapolating the total drag of ship models to full-scale conditions by the classical Froude method. The partial form factor is calculated from boundary-layer theory for an equivalent body of revolution representing the underwater hull of a surface ship.
(*g*) See (h).
(*h*) **A Modified Froude Method for Determining Full-Scale Resistance of Surface Ships from Towed Models, P. S. Granville,** *J. Ship Res.* **18**, 4, Dec. 1974.
Partial Form Factors from Equivalent Bodies of Revolution for the Froude Method of Predicting Ship Resistance, P. S. Granville, *Proc. 1st Ship Tech. and Research Symp.*, Aug. 1975, Soc. Naval Architects and Marine Engrg., N.Y.
The Drag and Turbulent Boundary Layer of Flat Plates at Low Reynolds Number, P. S. Granville, *J. Ship Research* **21**, 1, Mar. 1977.

334-09441-550-00

PROPELLER-HULL INTERACTION

(*b*) Naval Sea Systems Command.
(*c*) T. T. Huang, Hydrodynamics Branch.
(*d*) Experimental and theoretical work; applied research.
(*e*) Development of theoretical and computational methods to predict the effect of a propeller on thrust deduction and wake fraction. Experiments to determine propeller-induced boundary-layer velocity perturbations will be made with a laser-Doppler velocimeter.
(*g*) Theoretical and experimental work for axisymmetric bodies has been completed.
(*h*) **Propeller/Stern/Boundary-Layer Interaction on Axisymmetric Bodies: Theory and Experiment,** T. T. Huang, H. T. Wang, N. Santelli, N. C. Groves, *DTNSRDC Rept. 76-0113*, Dec. 1976.
Interaction of Afterbody Boundary Layer and Propeller, T. T. Huang, B. D. Cox, presented *Symp. Hydrodynamics of Ship and Offshore Propulsion Systems*, Hø vik, Oslo, Norway, 20-25 Mar. 1977 (sponsored by Det norske Veritas).

334-09442-030-00

FLOW TRANSITION AND TURBULENCE STIMULATION

(*b*) Naval Sea Systems Command..
(*c*) J. H. McCarthy, J. Power, Hydrodynamics Branch.
(*d*) Experimental work primarily; applied research.
(*e*) Determination of the locations of flow transition and laminar separation on axisymmetric models at Reynolds numbers of up to 4×10^7. Determination of effective turbulence-stimulation techniques and development of improved methods for predicting prototype drag from model drag measurements.
(*g*) Experiments on nine bodies have been completed.
(*h*) **The Roles of Transition, Laminar Separation, and Turbulence Stimulation in the Analysis of Axisymmetric Body Drag,** J. McCarthy, J. Power, T. Huang, *Proc. 11th ONR Symp. Naval Hydrodynamics*, London, Apr. 1976.
The Role of Boundary-Layer Transition in the Analysis of Model Resistance Experiments and Cavitation-Inception Scaling, J. McCarthy, *Proc. Intl. Sem. Ship Technology;* Seoul, Feb. 1976.
Drag, Flow Transition and Laminar Separation on Nine Bodies of Revolution Having Different Forebody Shapes, J. Power, *DTNSRDC Rept.*, 1977.

339-09444-520-20

NUMERICAL HYDROMECHANICS OF NAVAL VEHICLES

(*b*) Office of Naval Research and Naval Sea Systems Command.
(*c*) Dr. Nils Salvesen, Hydrodynamics Branch.
(*d*) Numerical and theoretical; applied research.
(*e*) Develop direct numerical methods for the prediction of those free-surface performance characteristics of Naval ships and advanced vehicles which cannot be satisfactorily predicted by conventional methods. Attention will be focused on the following problem areas: the nonlinear bow-wave; three-dimensional ship wave resistance; and the nonlinear surface-piercing strut.
(*g*) See publications.
(*h*) **Survey of Numerical Solution Techniques for Water Wave Problems,** C. von Kerczek, *1st Intl. Conf. Numerical Ship Hydrodynamics*, Oct. 1975, DTNSRDC (Organizer), Bethesda, Md. 20084.
Comparison of Numerical and Perturbation Solutions of Two-Dimensional Nonlinear Water Wave Problems, N. Salvesen, C. von Kerczek, *J. Ship Research*, 1976.
Numerical Solutions of Two-Dimensional Nonlinear Body-Wave Problems, N. Salvesen, C. von Kerczek, *1st Intl. Conf. Numerical Ship Hydrodynamics*, Oct. 1975, DTNSRDC (Organizer), Bethesda, Md. 20084.
Finite Difference Methods for Transient Potential Flows with Free Surfaces, H. J. Haussling, R. T. Van Eseltine, *1st Intl. Conf. Numerical Ship Hydrodynamics*, Oct. 1975, DTNSRDC (Organizer), Bethesda, Md. 20084.
Free-Surface Effects of Yawed Surface-Piercing Plates, R. B. Chapman, *J. Ship Research*, 1976.
Numerical Solution for Hydrodynamic Coefficients of a Surface-Piercing Strut, R. B. Chapman, *1st Intl. Conf. Numerical Ship Hydrodynamics*, Oct. 1975, DTNSRDC (Organizer), Bethesda, Md. 20084.
Numerical Analysis of Ship Maneuvering Problems, R. B. Chapman, presented *11th ONR Naval Hydrodynamics Symposium*, London, Apr. 1976.
A Variational Principle Associated with a Localized Finite Element Technique for Ship-Wave and Cavity Problems, B. Yim, *1st Intl. Conf. Numerical Ship Hydrodynamics*, Oct. 1975, DTNSRDC (Organizer), Bethesda, Md. 20084.
A Fast Fourth Order Laplace Solver for Application to Numerical Three-Dimensional Water-Wave Problems, S. Ohring, *1st Intl. Conf. Numerical Ship Hydrodynamics*, Oct. 1975, DTNSRDC (Organizer), Bethesda, Md. 20084.
A Localized Finite Element Method for the Uniform Flow Problems with a Free Surface, K. J. Bai, *1st Intl. Conf. Numerical Ship Hydrodynamics*, Oct. 1975, DTNSRDC (Organizer), Bethesda, Md. 20084.

334-10716-030-22

BODIES ON OR NEAR A FREE-SURFACE

(*b*) Naval Sea Systems Command.
(*c*) Dr. Ming-Shung Chang, Hydrodynamics Branch.
(*d*) Numerical and theoretical; applied research.
(*e*) Develop techniques to improve the predictions of ships' characteristics when operating on or near a free surface. Special problems of interest are the wave resistance of ships and three-dimensional effects on the prediction of ship motions in a seaway.
(*g*) See (h).
(*h*) **Hydrodynamic Forces on a Body Moving Beneath a Free Surface,** M. S. Chang, P. C. Pien, *1st Intl. Conf. Numerical Ship Hydrodynamics*, Bethesda, Md., 1975.
Velocity Potentials of Submerged Bodies Near a Free Surface–Application to Wave-Excited Forces and Motions, M. S. Chang, P. C. Pien, *11th Symp. Naval Hydrodynamics*, 1976.

334-10717-550-00

IMPROVED PREDICTIONS OF PROPELLER BLADE LOADS

(*c*) Dr. T. Brockett, Hydrodynamics Branch.
(*d*) Theoretical; applied research.
(*e*) Theoretical basis for predicting steady blade loading distributions for conventional subcavitating propellers exists in DTNSRDC Report 3880 for potential flow. Drag forces must be introduced empirically. Numerical analysis approach must be formulated and programmed for computer calculations. The final product will be a computerized tool for use in the design and analysis of propeller performance. The blade loading is of vital importance for stress analysis and cavitation predictions. The range of applicability of the program will be to operating conditions close to the design point.

334-10718-550-00

IMPROVED PREDICTION OF FLUCTUATING PROPELLER FORCES

(*c*) Dr. T. Brockett, Hydrodynamics Branch.
(*d*) Theoretical; applied research.
(*e*) An analytical investigation will be undertaken to develop equations to be programmed for the determination of the fluctuating forces produced by a given propeller operating in a nonuniform wake field. Two different types of singularities (vortex and dipole) will be analyzed and comments made as to the efficiency of computations. Better models for computing fluctuating forces will lead to reduced vibrations and improved cavitation predictions.
(*g*) The development of the dipole singularity representation is complete.

334-10719-520-00

PREDICTION OF MOTION OF MONO-HULL OR TWIN-HULL SHIPS

(*c*) K. K. McCreight, High Performance Craft Dynamics Branch.
(*d*) Theoretical; applied research.
(*e*) Development of computer program for predicting motion of mono-hull and twin-hull ships in waves was made.
(*f*) Completed.
(*g*) Motion in five degrees of freedom, except surge, in regular or irregular waves for arbitrary headings and speeds of conventional surface ships, catamarans, and small waterplane area, twin-hull ships can be computed; theoretical basis available in DTNSRDC Report 76-0046, 1976.
(*h*) **Manual for Mono-Hull or Twin-Hull Ship Motion Prediction Computer Program,** K. K. McCreight, C. M. Lee, *DTNSRDC Rept. SPD-686-02*, 1976.

334-10720-520-00

COMPUTATION OF WAVE LOADS ON TWIN-HULL SHIPS

(*c*) R. M. Curphey, Submarine Dynamics Branch.
(*d*) Theoretical; applied research.
(*e*) Development of computer program based on theoretical prediction of wave loads on cross structure and struts of twin-hull ships in beam waves was made.
(*f*) Completed.
(*g*) Analytical basis available in DTNSRDC Rept. 77-0027, 1977; computer program operational and provides the results which correlate with model experimental results excellently.
(*h*) **Computation of Loads Acting on the Cross Structure and Struts of Twin-Hull Ships in Beam Waves,** R. M. Curphey, *DTNSRDC Rept. SPD-651-01*, 1975.

334-10721-520-22

MOTION, STABILITY, AND WAVE LOAD OF TWIN-HULL SHIPS

(*b*) Naval Material Command.
(*c*) Dr. C. M. Lee, Ship Dynamics Division.
(*d*) Theoretical; applied research.
(*e*) Theoretical methods of predicting motion, vertical-plane stability and wave load of conventional catamarans and small waterplane area, twin-hull (SWATH) configurations were developed. Linear equations of motion formulated in frequency domain were used with the hydrodynamic coefficients obtained by strip theory. The hydrodynamic interactions between the two hulls, viscous damping, and stabilizing fin–body interactions are included in the hydrodynamic coefficients.
(*f*) Completed.
(*g*) Good agreement between predicted results and model experimental results confirmed the validity of the theoretical prediction methods. The theoretical methods are being utilized in the preliminary design stage of SWATH ships.
(*h*) **Theoretical Prediction of Motion of Small-Waterplane-Area, Twin-Hull (SWATH) Ships,** C. M. Lee, *DTNSRDC Rept. 76-0046*, 1976.
Determination of Size of Stabilizing Fins for Small Waterplane Area, Twin-Hull Ships, C. M. Lee, M. Martin, *DTNSRDC Rept. 4495*, 1974.
Theoretical Prediction of Dynamic Wave Loads on Small Waterplane Area, Twin-Hull Ships, R. M. Curphey, C. M. Lee, *DTNSRDC Rept. 77-0027*, 1977.
Prediction of Motion and Hydrodynamic Loads of Catamarans, C. M. Lee, H. D. Jones, R. M. Curphey, *Marine Technology* **10**, 4, 1973.

334-10722-520-22

HYDRODYNAMIC COEFFICIENTS OF A SMALL-WATER-PLANE-AREA, TWIN-HULL MODEL

(*b*) Naval Material Command.
(*c*) Dr. C. M. Lee, Ship Dynamics Division.
(*d*) Experimental work primarily; applied research.
(*e*) Experimental investigation of the hydrodynamic coefficients associated with the vertical-plane modes was made. The stability coefficients, motion-induced coefficients and wave-exciting coefficients were determined. Particular interest was placed on the hydrodynamic coefficients of fin-body interactions.
(*f*) Completed.
(*g*) Experimental results were compared with the theoretical results. Generally good agreement was obtained, especially for the damping contributed by the stabilizing fins.
(*h*) **Experimental Investigation of Hydrodynamic Coefficients of a Small-Waterplane-Area, Twin-Hull Model,** C. M. Lee, L. O. Murray, *DTNSRDC Rept. SPD 747-01*, 1977.

334-10723-520-00

MOTION CHARACTERISTICS OF FLOATING BODIES

(*c*) Dr. C. M. Lee, Ship Dynamics Division.
(*d*) Theoretical; basic and applied research.
(*e*) The motion characteristics of floating bodies, in and below a free surface, that are subjected to surface waves were examined. The effects of various degrees of approximation of hydrodynamic coefficients on the computed results of motion were investigated.
(*f*) Completed.
(*g*) For submerged bodies, the motion can be computed with satisfactory results with a crude approximation. If the added mass and wave-making damping are incorporated into the equation of motion, the wave-exciting term should include the wave-diffraction effects to predict motion correctly. Froude-Krylov hypothesis can lead into erroneous motion predictions.
(*h*) **Motion Characteristics of Floating Bodies,** *J. Ship Research* **20**, 4, 1976.

334-10724-520-22

AIR CUSHION VEHICLE LIFT SYSTEMS

(*b*) Naval Sea Systems Command. Research Administered by AALC Office, DTNSRDC, Code 118.
(*c*) George Wachnik, Code 118, David D. Moran, High Performance Craft Dynamics Branch.
(*d*) Theoretical, applied research.

(*e*) The static and dynamic behavior of the hydraulic (air supply and distribution) system which represents the lift system of an air cushion vehicle is investigated through the development of mathematical models and the examination of experimental data collected for model and full-scale compressors and air distribution systems. The dynamic performance of large centrifugal and mix-flow compressors which are subject to periodic variations in the downstream or exit pressure are of particular importance. The purpose of the research is to provide methods for the design of increased efficiency ACV lift systems for operation in ocean waves.
(*g*) ACV lift sytems are subject to a hysteresis response in the performance characteristics. Compressors operated under dynamics conditions in an ACV exhibit looped performance curves (pressure-discharge fan maps) which deviate significantly from static (zero frequency) performance curves.
(*h*) **Air Cushion Vehicle Fan Dynamic Response: A Review of the Literature,** D. D. Moran, *DTNSRDC Rept. SPD-695-01*, June 1976.

334-10725-520-22

MOTIONS OF PLANING BOATS IN WAVES

(*b*) Naval Sea Systems Command.
(*c*) Dr. M. Martin, Ship Dynamics Division.
(*d*) Theoretical, applied research.
(*e*) A theoretical method is derived for predicting the linearized response characteristics of constant deadrise, high-speed planing boats in head and following seas.
(*f*) Completed.
(*g*) Comparisons of the theoretical predictions of the pitch and heave response-amplitude operators and phase angles with existing experimental data show reasonably good agreement for a wide variety of conditions of interest. Notwithstanding severe nonlinear effects near the resonance encounter frequency as the speed approaches the porpoising limit, it is concluded that the linear theory in its present form can serve as a useful design tool, especially since it has already been shown that the effect of hull parameters on performance as obtained from data in the linear range is valid for operation in realistic seas.
(*h*) **Theoretical Prediction of the Motions of High Speed Planing Boats in Waves,** M. Martin, *DTNSRDC Rept. 76-0069;* also submitted to *J. Ship Research* in Jan. 1977.

334-10726-520-22

PORPOISING OF PLANING BOATS

(*b*) Naval Sea Systems Command.
(*c*) Dr. M. Martin, Ship Dynamics Division.
(*d*) Theoretical, applied research.
(*e*) A theoretical method is derived for predicting trim angle and speed coefficient at the inception of porpoising of prismatic planing hulls.
(*f*) Completed.
(*g*) Comparisons of theoretical predictions with existing experimental data on porpoising for a wide range of operating conditions, show generally good agreement. The theory may also be used for estimating the natural frequencies and damping characteristics of the boat in the stable planing range. It was also shown that the surge degree of freedom has only a very small effect on porpoising.
(*h*) **Theoretical Determination of Porpoising Instability of High-Speed Planing Boats,** M. Martin, *DTNSRDC Rept. 76-0068*, Apr. 1976; also submitted to *J. Ship Research* in Oct. 1976.

334-10727-030-22

DYNAMICS OF BUOY-CABLE-BODY SYSTEMS

(*b*) Naval Air Development Center.
(*c*) Dr. Henry T. Wang, Hydrodynamics Branch.
(*d*) Theoretical/numerical; applied research.
(*e*) A FORTRAN IV computer program has been developed for the time domain analysis of the two-dimensional dynamic motions of general buoy-cable-body systems. A variety of shapes are used to model the surface buoy and intermediate bodies. The cable is modeled by a series of finite elements.
(*g*) The computer program has been shown to be applicable for a wide variety of cable systems. It is currently being validated by a series of full-scale tests.
(*h*) **A FORTRAN IV Computer Program for the Time Domain Analysis of the Two-Dimensional Dynamic Motions of General Buoy-Cable-Body Systems,** H. T. Wang, *DTNSRDC Rept. 77-0046*, 1977.

334-10728-010-22

BOUNDARY LAYER STABILITY AND TRANSITION

(*b*) Naval Sea Systems Command.
(*c*) Dr. C. von Kerczek, Hydrodynamics Branch.
(*d*) Theoretical/numerical; applied research.
(*e*) Development of efficient computer method based on Smith-Van Ingen linear stability "e^9" method to predict transition in planar or axisymmetric, heated or unheated and with or without suction, boundary layers. Three-dimensional perturbations to flow, geometry and/or heating will be considered.
(*g*) Computer program for unheated flows completed.

334-10729-010-22

ASPECTS OF BOUNDARY LAYERS

(*b*) Naval Sea Systems Command.
(*c*) Dr. C. von Kerczek, Hydrodynamics Branch.
(*d*) Theoretical/numerical; applied research.
(*e*) Development of methods and computer programs for calculating three-dimensional turbulent boundary layers on ships' hull.
(*g*) Three-Dimensional Cumpsty-Head momentum-integral method with small cross flow approximation for ships' hull completed. Extension to arbitrary crossflow underway.

334-10730-550-22

THE EFFECT OF MODEL SIZE ON PROPELLER PERFORMANCE CHARACTERISTICS

(*b*) Naval Sea Systems Command, Code 037.
(*c*) Mr. Richard Hecker, Code 1524.
(*d*) Experimental, applied research.
(*e*) It has been observed over the years that geometrically similar model propellers of different sizes seem to have different characteristics especially in open-water. Analysis and a literature survey have shown this to be generally true. Further investigation has led to the belief that three-dimensional pressure gradients due to centrifugal forces affect the transition to turbulent boundary layer on the blades.
(*g*) Only a small part of the experimental program has been completed but results to date show a systematic change in propeller characteristics with model propeller size. In general for pitch-ratio less than 1.0 the smaller propeller gives the highest force coefficients while for higher pitch-ratios the reverse is true.

334-10731-550-22

PROPELLER-HULL INTERACTION COEFFICIENTS IN STOPPING OF SHIPS

(*b*) Naval Sea Systems Command, various codes.
(*c*) Mr. R. Hecker, Code 1524.
(*d*) Experimental, applied research.
(*e*) Computer simulations are made to predict how fast a ship can be stopped without exceeding any limits throughout the propulsion train from prime mover to propeller. The input to this simulation are the dynamics of the propulsion system and the propeller. In addition the transient hull interaction coefficients must be included.
(*g*) The transient coefficients are approximated by performing quasi-steady model experiments over a wide range of conditions. This has been done for several ships and reports are being written. It has been concluded that there is enough difference in the interaction coefficient that it is desirable, if not necessary, to perform these experiments.

334-10732-550-22

FEASIBILITY OF OVERLAPPING, PARTIALLY SUBMERGED, SUPERCAVITATING PROPELLERS

(*b*) Naval Sea Systems Command, Code PMS 304.
(*c*) Mr. Robert F. Roddy, Code 1524.
(*d*) Experimental, applied research.
(*e*) An investigation into the feasibility of using overlapping partially submerged, supercavitating propellers as the means of propulsion for large surface effect ships was carried out. The rationale for this work is that partially submerged propellers should produce higher efficiency, and longer range than waterjets.
(*f*) Temporarily suspended.
(*g*) This method of propulsion is shown to be feasible and a performance estimate is developed for an 8,000 ton surface effect ship with a cushion length to beam ratio of 5. Most significantly, overlapping, partially submerged, supercavitating propellers were demonstrated to be feasible with the performance of each propeller in the set approximating that of a single propeller in undisturbed flow.
(*h*) **Investigation of the Feasibility of Propelling Large Surface Effect Ships with Widely Spaced, Partially Submerged, Supercavitating Propellers,** R. F. Roddy, *DTNSRDC Rept. SPD-742-01*, Dec. 1976 (obtain from DDC).
High Performance Marine Propellers–An Overview, R. Hecker, R. J. Altman, *ASME Marine Propulsion, OED* 2, Dec. 1976.
Experimental Performance of a Partially Submerged Propeller in Inclined Flow, R. Hecker, *SNAME Paper F*, Spring Mtg., Apr. 1973.

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NAVAL SURFACE WEAPONS CENTER, White Oak, Silver Spring, Md. 20910. Mr. J. Colvard, Technical Director.

335-04867-510-22

HYDROBALLISTICS RESEARCH

(*b*) NAVSEA.
(*c*) J. A. Iandolo, Head, Hydrodynamics and Applied Mechanics Branch.
(*d*) Experimental, theoretical; basic and applied research.
(*e*) Under the hydroballistics research program experimental and theoretical research is being conducted to solve immediate and long-range Navy problems in high-speed water entry, underwater launching of ordnance from moving submarines, mine case motion and dynamics, and new weapon system synthesis in these technical areas.
Specifically the water-entry research program is aimed at providing basic data on forces and moments that can be used in the design of Naval ordnance that is required to enter the water at high velocity. As part of the program the ability to predict the complete underwater trajectory of the ordnance after entering the water is also being developed.
In order to accomplish this, extensive studies are being made of the cavity-running phase involving cavity growth and attrition, and cavity pressure. The NAVSURFWPNCEN Hydroballistics Facility measuring 35 ft × 100 ft × 70 ft is ideally suited for these studies since it permits atmospheric pressure reduction for cavitation scaling.
The underwater launch program is directed at establishing the actual flow conditions, forces and moments that exist during the launch of the missiles or torpedoes from moving submarines. The ultimate goal is to increase the weapon launch capability and flexibility of existing and future Naval submarines.
(*g*) Results of recent studies include prediction of water-entry impact drag coefficients for cones, ogives, blunt nose shapes; experimental determination of cavity pressure and approximate techniques for estimating cavity size. Shock spectra for blunt nose mine shapes have been obtained from model tests which agree with full-scale tests. Methods of stabilizing slender vehicles so that they can enter the water at high speed and low entry angle without broaching were developed. In the area of underwater launch, a simple method of stabilizing a missile when launched from a vertical tube on a moving submarine was developed.
(*h*) **Vertical Water Entry of Spheres,** J. L. Baldwin, H. K. Steves, *NSWC/WOL/TR 75-49*, May 7, 1975.
An Experimental Investigation of the Axial Forces Generated by the Oblique Water Entry of Cones, J. L. Baldwin, *Shock and Vibration Bull. No. 46*, Aug. 1976.
Estimated Hydrodynamic Coefficients for a High Performance Vehicle, C. W. Smith, *NSWC/WOL/TR 76-27*, Apr. 1, 1976.
Analytical Model for Predicting the Dynamic Behavior of Cavities, C. W. Smith, *NSWC/WOL/TR 76-114*, Dec. 1976.
Prediction of Impact Pressures, Forces, and Moments During Vertical and Oblique Water Entry, Dr. A. B. Wardlaw, Dr. A. M. Morrison, Dr. J. L. Baldwin, *NSWC/WOL/TR 77-16, Jan. 15, 1977.*

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NAVAL UNDERWATER SYSTEMS CENTER, NEW LONDON LABORATORY, New London, Conn. 06320. Capt. W. L. Bohannan, Commanding Officer; Dr. C. N. Pryor, Technical Director.

336-09453-160-22

FLOW-INDUCED NOISE PREDICTIONS FOR AN IDEALIZED SONAR DOME

(*b*) Chief of Naval Material (MAT 03L4).
(*c*) Russell Christman, Mechanical Engineer.
(*d*) Theoretical; basic research.
(*e*) The characteristics of the pressure field generated by infinite and finite plates excited by turbulent boundary layer flow in the presence of heavy fluid loading are examined.
(*f*) Completed.
(*g*) In estimating flow-induced noise, the effects of the fluid environment on the plate are important and represent forces to the plate that may be interpreted as both inertial and resistive forces. Not including all the effects of the fluid leads to substantial errors in the estimation of flow-induced noise. A comparison of finite and infinite plate pressure spectra reveals that only at the surface of the plate does the infinite plate provide a good estimate of the finite plate pressure.
(*h*) **Installation of a Rectangular Test Section for Acoustic Water Tunnel Studies of Flow-Induced Noise,** H. H. Schloemer, *NUSC Tech. Rept. No. 4763*, Aug. 21, 1974.

336-09454-240-29

FLUID FINITE ELEMENT DEVELOPMENT

(*b*) Department of Defense.
(*c*) A. D. Carlson, Engineering Mechanics.
(*d*) Applied research.
(*e*) Calculate the response of a structure in a fluid subjected to pressure pulses.
(*g*) Continued reasonable correlation between analysis and several experiments.
(*h*) **A Summary of NASTRAN Fluid/Structure Interaction Capabilities,** *5th NASTRAON Users Colloquium*, Oct. 5-6, 1976, A. J. Kalinowski, J. S. Pattel, *NASA TM X-3428*, Oct. 1976.

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NAVAL UNDERWATER SYSTEMS CENTER, NEWPORT LABORATORY, Newport, R. I. 02840. Captain W. L. Bohannan, Commanding Officer; Dr. C. N. Pryor, Technical Director.

337-09455-250-00

DRAG REDUCTION MECHANISM; POLYSTYRENE

(*c*) R. H. Nadolink, Project Engineer.

(*d*) Experimental; basic research.
(*e*) Using special ultra high molecular weight, nearly monodisperse, polystyrene, conduct experiments to elucidate the mechanism of polymeric friction reduction. Since polystyrene is easily characterized and many solvent/non-solvent systems are available, although they are non-aqueous, and a family of molecular weights available, meaningful experiments can be conducted with clear results. Also, different solvent-temperature reactions can be tested. This is clearly opposed to experiments conducted with commercially available poorly characterized bulk polymers of broad molecular weight distribution and limited solvent systems. Preliminary results clearly indicate that the flow/molecular relaxation time scales are the controlling parameter in achieving high friction reductions with very dilute polymer solutions. Work will be completed in 1978 with a formal report summarizing results.
(*h*) **Friction Reduction in Dilute Solutions of Polystyrene: Part 1,** R. H. Nadolink, *NUSC TR 4422*. May be obtained by contacting R. H. Nadolink, NUSC, Newport Lab. Code 3635.

337-09456-250-22

POLYMER NOISE-DRAG REDUCTION: ADVANCED APPLICATIONS

(*b*) Naval Sea Systems Command.
(*c*) M. Cincotta, Chemical Engineer.
(*d*) Experimental; basic and applied research.
(*e*) Construct a facility which will incorporate a laser Doppler velocimeter and a special rectangular test section to determine boundary layer diffusion; boundary layer polymeric hydration; turbulent intensity effects of polymers; and controlling factors in boundary layer hydration of polymers. These results should begin to describe the mechanism of polymeric friction reduction and allow for tailoring of polymer ejection schemes for specific applications. Basic calibration has been completed and baseline diffusion data taken with a unique laser system which measures both velocity profiles and concentration gradients. Final reports have been issued.
(*f*) Completed.
(*h*) **Design, Construction, and Initial Measurements in the Water Tunnel Facility Utilizing Laser Doppler Anemometry,** M. Cincotta, *NUSC TM-SB323-4054-76*.
Experimental Investigation of the Dispersion of Particles in a Flat Plate Boundary Layer Using a Laser Doppler Anemometer, L. Dinola, *M.S. Thesis*, Univ. of Rhode Island, 1975.

TENNESSEE VALLEY AUTHORITY, DATA SERVICES BRANCH, Knoxville, Tenn. 37902. Mr. Claude H. Smith, Branch Chief.

338-0261W-810-00

PINE TREE BRANCH WATERSHED

For summary, see Water Resources Research Catalog **6**, 2.1304.

338-00765-810-00

EVAPORATION IN THE TENNESSEE BASIN

(*d*) Field investigation; applied research.
(*e*) To provide data for estimating reservoir losses and derive a general rule, applicable to the Basin, permitting computation of evaporation from pans at six locations in Basin, together with standard meteorological readings.
(*h*) Results published in monthly and annual bulletins, *Precipitation in Tennessee River Basin* (Project 00768).

338-00768-810-00

PRECIPITATION IN TENNESSEE RIVER BASIN

(*d*) Field investigation; basic research.
(*e*) A comprehensive study of rainfall and other weather phenomena for purposes of water dispatching and improvements in water control; storm studies as related to maximum precipitation, rainfall-runoff, spillway design and operation, etc.
(*h*) Monthly and annual bulletins, *Precipitation in Tennessee River Basin*.

338-00769-860-00

RESERVOIR AND STREAM TEMPERATURES

(*d*) Field investigation; basic research.
(*e*) Study of water utilization and water movement as concerns industrial and steam plant locations and stream pollution. Variations in temperature from surface to bottom in selected reservoirs are determined by soundings, and by continuous recording gages in selected natural streams. Periodic observations are made at gaging stations.

338-00771-350-00

GALLERY DRAINAGE IN LARGE DRAINS

(*d*) Field investigations; design.
(*e*) Weirs are placed in main galleries and drainage measured as check on tightness and stability.

338-00785-350-00

SEDIMENTATION OF EXISTING RESERVOIRS

(*d*) Field investigation; design and operation.
(*e*) Selected ranges in reservoirs are probed and sounded, volumetric samples are collected and analyzed, quantity and distribution of sediment are computed to determine deposition by stream, probable life of reservoir, effect of sediment storage on navigation channels and sedimentation of down-stream reservoirs, and probable sedimentation in future reservoirs.
(*h*) **Sedimentation in TVA Reservoirs,** *Rept. No. 0-6693*, TVA, Feb. 1968.

TENNESSEE VALLEY AUTHORITY, WATER RESOURCES MANAGEMENT METHODS STAFF, Knoxville, Tenn. 37902. Walter O. Wunderlich, Supervisor.

339-08575-800-00

DEVELOPMENT OF WATER RESOURCES MANAGEMENT METHODS

(*d*) Theoretical; applied research.
(*e*) The project will develop for the Tennessee River system comprehensive procedures which will allow current evaluation and consideration of all essential objectives, such as navigation, flood control, power production, water quality management, water supply and recreation. The methods will be used as day-to-day decision aids for TVA's water resource planning and management activities. They will expand the present decision-making process by using more comprehensive and automated procedures which can respond to the steadily increasing complexities of water quantity and quality management.
(*h*) List of reports available on demand.

TENNESSEE VALLEY AUTHORITY, WATER SYSTEMS DEVELOPMENT BRANCH, Drawer E, Norris, Tenn. 37828. E. Ely Driver, Laboratory Director.

341-07080-340-00

RACCOON MOUNTAIN–HYDRAULIC TRANSIENT STUDIES

(*d*) Field investigations.
(*e*) Measurements of water hammer and surges during initial operation and acceptance testing of the pump/turbines.

Transient flows, pressures, surge magnitude, gate openings, shaft torque, etc., will be measured and recorded simultaneously during simulated load rejection and pump power failure.

341-07083-870-00

BROWNS FERRY NUCLEAR PLANT–CONDENSER-WATER THERMAL DIFFUSION IN A THREE-DIMENSIONAL MODEL

(*d*) Applied research; for design.
(*e*) Condenser cooling water is mixed with the flow in Wheeler Reservoir by means of three diffuser pipes. Flows through Wheeler Reservoir are controlled by two hydro projects, Wheeler and Guntersville Dams. These projects, operated for peaking power requirement purposes, cause highly variable flows in Wheeler Reservoir. A distorted scale model, supplied with inflows of heated and cooled water to simulate the condensate cooling problem, is being used to develop water temperature information.
(*g*) Data from the field will be taken, under several combinations of river flows and discharge conditions, so that comparisons may be made with model study results.

341-08570-860-00

FORT PATRICK HENRY REOXYGENATION STUDIES

(*d*) Field investigation; experimental.
(*e*) Tests on the performance of small oxygen bubble reaeration technique for increasing the dissolved oxygen in turbine discharges. At a pilot setup at Fort Patrick Henry Dam, measurements were made of oxygenation uptake efficiency as a function of water flow rate, oxygen flow rate, placement of the oxygen bubble generators and their pore size. Flows up to 4400 cfs were used. Calculations of cost of a full scale system and its sensitivity to variations in the design were made.
(*f*) Completed.
(*g*) A final report of the study will be available in the summer of 1977.

341-09458-870-00

WIDOWS CREEK STEAM PLANT SULPHUR DIOXIDE SCRUBBER

(*d*) 1:16 scale model study for design.
(*e*) A plexiglas model using hot air, cold air and water was used to study the countercurrent air/water flow and hot air/cold air reheater performance. Design information was generated on guide vanes, baffle plates, grids, demister and reheater gas mixing capacity for a particular duct configuration. In addition spray nozzle tests were made to determine pressure loss and drop size distributions for 1:1, 1:2, 1:4 and 1:8 scale geometrically similar nozzles. The results of these tests were used to simulate the water spray in the 1:16 scale gas duct model.
(*f*) Completed.
(*g*) Results of these tests were presented in internal TVA reports to the sponsoring organization.

341-09460-340-00

RACCOON MOUNTAIN PUMPED-STORAGE PROJECT, HYDRAULIC TRANSIENT STUDIES, NUMERICAL MODEL

(*d*) Applied research; for design.
(*e*) A numerical model was used to develop information for estimating the effects of changes in the tunnel system at Raccoon Mountain due to variations in mode of operations. A change from one steady-state to another such as due to turbine load acceptance, turbine load rejection or pump power loss would subject the tunnel system to transient pressures and produce fluid mass oscillations in the surge tank.
(*f*) Completed.
(*h*) A monograph delineating the two numerical schemes which can be used to describe this type of transient flow behavior, the method of characteristics and the implicit method, is being prepared.

341-10733-350-00

COLUMBIA DAM SPILLWAY STRUCTURE

(*d*) Model study for design.
(*e*) A 1:80 scale hydraulic model was used to develop spillway capacity curves, stilling basin geometry by scour tests, water surface profiles for training wall design, velocities and wave heights for riprap protection.
(*f*) Completed.
(*g*) A set of Advance Reports covering the results of the various aspects of the model study have been issued to Division of Engineering Design.

341-10734-870-00

HYDROTHERMAL PHYSICAL MODELING OF THERMAL DISCHARGE DIFFUSERS

(*d*) Applied research; for design.
(*e*) The performance of multiport diffuser systems for the discharge of blowdown from closed cycle cooling systems at steam electric generating plants is studied using physical hydraulic models. Positively or negatively buoyant discharges are modeled using temperature as an indicator of diffuser induced dilution and plume structure. Multiport diffusers are modeled using the equivalent slot concept, which equates port size and spacing to an equivalent slot of equal length and port area.
(*h*) **Effect of Orientation to Flow Direction on Diffuser Induced Dilution and Plume Structure in a Shallow River,** C. D. Ungate, E. E. Driver, *XVIIth Congr. Intl. Assoc. Hydraulic Research*, Baden-Baden, Germany, Aug. 15-19, 1977.

341-10735-340-00

SEQUOYAH AND WATTS BAR NUCLEAR PLANTS–RHR SUMP VORTEX STUDIES

(*d*) Experimental model study for design.
(*e*) Prior to licensing of nuclear generating plants, the efficacy of the Residual Heat Removal system must be demonstrated. Plans are underway to construct a scale model of the containment structure and the sump from which the RHR pumps take suction. The aim of the study is to develop a geometry which results in no air entraining vortices at the sump.

341-10736-330-00

PICKWICK LANDING NAVIGATION LOCK STUDY

(*d*) Experimental model study for design.
(*e*) A new navigation lock is to be added at the Pickwick Landing Dam. The new lock will be 110 × 1000 feet long with a maximum lift of about 65 feet. This will be the longest lock on the Tennessee River and it will be designed with TVA's multi-port filling and emptying system. The 1:25 scale model of the upstream approach, the lock chamber, and the downstream approach will be used to check the adequacy of the filling and emptying system. Transient pressures, surges, waves, and hawser forces will be measured. The object of the study is to minimize lock filling and emptying times and also the water turbulence and hawser forces.

341-10737-850-00

SURVIVAL OF LARVAL FISH IMPINGED ON FINE MESH SCREENS

(*d*) Experimental biological laboratory and field study–basic research.
(*e*) Basic data is sought on the feasibility of screening larval fish from a pump intake to mitigate adverse impact on the fish population. Measurements were made in the laboratory of the degree of entrainment and mortality of fish impinged on fine mesh screens by flow normal to the screen for different time intervals and approach velocities. Screens with openings from 0.5-2 mm were tested under velocities from 0.5-2 fps with larval fish sized from 4-8 mm for impingement times of up to 8 minutes. Several fish species were tested. Also panels of fine mesh screens were

mounted on an existing condenser cooling water intake for a coal fired steam generating plant equipped with standard vertical traveling screens, and the size and numbers of impinged larval fish were analyzed and compared to the laboratory tests.

(*f*) Completed.

(*g*) Final report will be completed in the summer of 1977.

341-10738-850-00

MODIFICATIONS OF VERTICAL TRAVELING SCREENS TO IMPINGE AND RELEASE UNHARMED LARVAL FISH

(*d*) Experimental, biological, laboratory tests for design.

(*e*) A laboratory apparatus has been constructed by means of which the vertical motion of traveling screen baskets can be simulated. The test basket with fine mesh screening material is made to move through a stream of water, through the air and through a circular, emptying motion. The mortality of larval fish will be studied for different species, different screen mesh sizes, varying approach velocities and simulated screen traveling times. The effects of stress points like impingement, removal from the stream, washing off the screen, and dumping into a return sluice will be studied separately. Modifications to the screening system will be made to obtain improved larval fish mortality.

341-10739-340-00

BROWNS FERRY NUCLEAR PLANT–COOLING TOWER LIFT CIRCUIT TESTS

(*d*) Experimental, field investigations for operations.

(*e*) Used condenser cooling water is pumped up to the top of mechanical draft cooling towers. Measurements have been made on the pumps, the pipes and the cooling towers as part of the acceptance testing. Measurements of pump vibrations, pump performance, pressures, pressure pulsations, hydraulic transients, cooling tower flow distribution, water temperatures, and water flow rates have been made. The flow rate measurements were made with especially constructed and calibrated pitot-meter probes traverses.

341-10740-870-00

THERMAL DISPERSION AND FLUID DYNAMICS MODELING

(*b*) Environmental Protection Agency.

(*d*) Theoretical; applied research.

(*e*) Computer models are being developed for analyzing the effects of thermal discharges from steam plants on temperatures and velocities in the receiving body of water. A three-dimensional, unsteady model provides relatively fine scale resolution within approximately a 10-kilometer reach of the plant. A two-dimensional, unsteady model is used for analyzing an entire reservoir or a long reach of river.

(*h*) **Analysis of the Thermal Effluent from the Gallatin Steam Plant During Low River Flows**, W. R. Waldrop, F. B. Tatom, *Tech. Rept. No. 33-30*, June 1976.

341-10775-850-00

INTAKE AVOIDANCE TESTS WITH LARVAL FISH

(*d*) Experimental biological laboratory tests–basic research.

(*e*) A test flume is used to study the capability of larval fish of different species to avoid impingement on a slotted, wedge-wire screen when the approach velocity is parallel to the screen surface and flow is provided by passing the screen. Screens are tested in both the horizontal and vertical positions, with different slot widths and for different bypass flow ratios.

U.S. DEPARTMENT OF TRANSPORTATION, FEDERAL HIGHWAY ADMINISTRATION, Office of Research, HRS-42, Washington, D. C. 20590. Charles F. Scheffey, Director of Research.

342-08577-360-00

ENERGY DISSIPATORS FOR CULVERTS AND HIGHWAY DRAINAGE STRUCTURES

(*c*) J. S. Jones.

(*d*) Experimental, applied research.

(*e*) Investigation of various schemes of dissipating the erosive force of water in highway drainage structures has been completed. The investigation included a survey of energy dissipation practices used by highway agencies. The investigators developed design procedures based on past research reports and on recent laboratory testing of transverse roughness bars placed along the culvert floor.

(*g*) A circular was prepared to provide design information for energy dissipation at culvert outlets and in open channels. Design information is included for the following types of dissipators: hydraulic jump, forced hydraulic jump, impact basin, drip structure, and preformed scour holes lined with riprap.

(*h*) **Hydraulic Design of Energy Dissipators for Culverts and Channels**, *Hydraulic Engrg. Circular No. 14*, FHWA, Office of Engrg., Washington, D.C. 20590, Dec. 1975.

PROJECT REPORTS FROM CANADIAN LABORATORIES

ACRES CONSULTING SERVICES LIMITED, 5259 Dorchester Road, Niagara Falls, Ontario L2E 6W1, Canada. Dr. I. K. Hill, Head, Hydraulic and Environmental Departments.

400-08156-340-75

NINE-MILE POINT THERMAL MODEL STUDY

(*b*) Quirk, Lawler and Matusky, Engineers.
(*c*) Mr. B. Pomerhn, Acres American Incorporated, Consulting Engineers, Liberty Bank Building, Main at Court, Buffalo, New York 14202.
(*d*) Experimental, for design purposes.
(*e*) Construction and testing of a thermal hydraulic model to study thermal discharge into Lake Ontario by cooling water from the Niagara Mohawk Power Corporation Nine-Mile No. 1 and No. 2 units. The 1:80 undistorted scale model covered a lake area 8,800 feet by 14,000 feet. Automated data acquisition and processing by computer was utilized during testing.
(*f*) Study complete, report submitted to client.
(*g*) The study demonstrated acceptable dispersion patterns and surface temperatures under normal operating conditions.

400-09468-340-75

PERRY THERMAL MODEL STUDY

(*b*) NUS Corporation.
(*c*) Mr. D. Mayer, Acres American Incorporated, Consulting Engineers, Liberty Bank Building, Main at Court, Buffalo, New York 14202.
(*d*) Experimental, for design purposes.
(*e*) Design, construction and testing of a thermal hydraulic model to study cooling water discharge into Lake Erie from proposed Perry Nuclear Power Plant (2,468 Mw) of Cleveland Electric Illuminating Company. The 1:75 undistorted scale model covered a prototype lake area 6,500 feet by 8,000 feet. Representative ambient currents, including onshore currents, were tested. Automated data acquisition and processing by computer were utilized during testing.
(*f*) Study complete, report submitted to client.
(*g*) The study demonstrated acceptable dispersion patterns and surface temperatures under normal operating conditions.

400-09472-330-20

ST. MARY'S RIVER ICE MODEL

(*b*) U.S. Corps of Engineers.
(*c*) Dr. J. Hayden, Acres American Inc., Consulting Engineers, Liberty Bank Building, Main at Court, Buffalo, N.Y. 14202.
(*d*) Experimental, for design purposes.
(*e*) An undistorted 1:120 scale model of a portion of the St. Mary's River has been modeled to assess alternative means of ice control to assist winter navigation. The model covers a prototype length of 22,320 feet, and reproduces existing topography and underwater contours.
(*f*) Study complete, report submitted to client.
(*g*) The model simulated the effects of relocating the ferry crossing, widening of the riverbed, the use of ice control booms and ice harvesting methods, the creation of ice-flow diversions and ice suppression systems. Remedial measures recommended as a result of the study and put into service in the winter of 1975-76 have proven highly successful.

400-09477-340-75

BRANDON SHORES STATION PRECIPITATOR

(*b*) Gilbert Associates.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) The insertion of an electrostatic dust precipitator into the flues of an existing thermal power plant generally requires extensive and complicated duct work. The requirements of minimizing head losses in the duct work and achieving a uniform flow distribution through the precipitator to maintain a high degree of efficiency require model studies. A scale model of the precipitator and its dust collector curtains, hoppers, etc., and associated duct work was used for the study. The model was manufactured in Plexiglas with the exception of the collector curtains, which were from steel.
The study is concerned with the necessity to distribute the gas glow evenly over the collector curtains with the minimum of turbulence and head loss. In the approach duct work, space restrictions dictate short radius bends so that the placing of guide vanes and diffuser screens constitutes the main part of the program. The study also includes an investigation of the flow conditions in the duct work with particular reference to the location of possible areas of dust buildup. An anemometer with automatic traversing and plotting capabilities is employed to ensure uniformity of readings and continuous recording of the velocity profiles. 2,819,000 ACFM, 650°, 660 MW.
(*f*) Study complete. Report submitted to client.

400-09485-340-70

1300-MW UNIT AMERICAN ELECTRIC POWER PRECIPITATOR

(*b*) Wheelabrator-Frye.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) See 400-09477-340-75. 563,000 ACFM, 1300 MW.
(*f*) Study complete, report submitted to client.

400-09486-340-70

JADISON COUNTY STEAM PLANT, UNIT I, MISSISSIPPI POWER PRECIPITATOR

(*b*) Western Precipitation Division, Joy Manufacturing Company.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) See 400-09477-340-75.
(*f*) Study complete. Report submitted to client.

400-09488-340-70

ROY S. NELSON STATION PRECIPITATOR, GULF STATES UTILITIES COMPANY

(*b*) Western Precipitation Division, Joy Manufacturing Company.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) See 400-09477-340-75. 755,000 ACFM.
(*f*) Study complete. Report submitted to client.

400-09489-340-75

WYODAK STATION, BLACK HILLS PRECIPITATOR

(*b*) Babcock and Wilcox.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) See 400-09477-340-75. 1,812,000 ACFM.
(*f*) Study complete, report submitted to client.

400-09490-340-70

UNIVERSAL SLAB MILL HOT SCARFER FACILITY PRECIPITATOR, JONES AND LAUGHLIN STEEL CORPORATION

(*b*) Western Precipitation Division, Joy Manufacturing Company.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) See 400-09477-340-75. 125,000 ACFM.
(*f*) Study complete, report submitted to client.

400-09491-340-70

WHITING REFINERY PRECIPITATOR, AMOCO OIL COMPANY

(*b*) Precipitair Pollution Control.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) See 400-09477-340-75. 298,200 ACFM, scale 1:12.
(*f*) Study complete, report submitted to client.

400-10474-340-73

PENNSYLVANIA POWER AND LIGHT PRECIPITATOR

(*b*) Pennsylvania Power and Light Company.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) See 400-09477-340-75.
(*f*) Study complete. Report submitted to client.

400-10475-340-75

CALGARY POWER PRECIPITATOR

(*b*) Research–Cottrell (Canada) Limited.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) See 400-09477-340-75.
(*f*) Study complete. Report submitted to client.

400-10476-340-70

JOS. E. SEAGRAM PRECIPITATOR

(*b*) American Air Filter.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) See 400-09477-340-75.
(*f*) Study complete. Report submitted to client.

400-10477-340-70

CO-OP POWER AND UNITED POWER PRECIPITATOR

(*b*) Wheelabrator–Frye.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) See 400-09477-340-75.
(*f*) Study complete. Report submitted to client.

400-10478-340-75

CINCINNATI PRECIPITATOR

(*b*) Research–Cottrell (Canada) Limited.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) See 400-09477-340-75.
(*f*) Study complete. Report submitted to client.

400-10479-340-70

BRASCEP PRECIPITATOR

(*b*) Electrosul.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) See 400-09477-340-75.
(*f*) Study complete. Report submitted to client.

400-10480-340-70

LAWRENCEBURG PRECIPITATOR

(*b*) American Air Filter.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) See 400-09477-340-75.
(*f*) Study complete. Report submitted to client.

400-10481-340-70

MAYO PLANT PRECIPITATOR

(*b*) Belco.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) See 400-09477-340-75.

400-10482-340-70

GEORGIA POWER PRECIPITATOR

(*b*) Western Precipitation Division, Joy Manufacturing Company.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) See 400-09477-340-75.

400-10483-340-70

BIG RIVERS PRECIPITATOR

(*b*) American Air Filter.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) See 400-09477-340-75.

400-10484-340-70

SASKATCHEWAN POWER PRECIPITATOR

(*b*) American Air Filter.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) See 400-09477-340-75.

400-10485-340-70

H. S. STEEL BAGHOUSE

(*b*) Wheelabrator–Frye.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) Baghouses are an effective means of removing particulates from flue gases. The duct work leading to and from the bags is complicated and difficult to design to ensure equal gas flow to all bags and that the pressure drop is minimal. Laboratory modeling provides the best way of ensuring that field units operate as required.
(*f*) Study complete. Report submitted to client.

400-10486-340-70

LOUISVILLE/CANE RUN SCRUBBERS

(*b*) American Air Filter.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) Gas scrubbers installed in the flue gas systems remove both particulates and sulphur dioxide. Their design must ensure that pressure drops are reduced to a minimum; separation of water droplets from the gas achieves the effluent requirements; diluting stack gas with hot gas is effective in raising the temperature of the stack gas above dewpoint.
(*f*) Study complete. Report submitted to client.

400-10487-340-70

CANE RUN QUENCHER

(*b*) American Air Filter.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) Same as (e) above (scrubbers).
(*f*) Study complete. Report submitted to client.

400-10488-340-70

CANE RUN CHEVRON DRYER

(*b*) American Air Filter.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) Same as (e) above (scrubbers).
(*f*) Study complete. Report submitted to client.

400-10489-340-70

MILL CREEK 3 SCRUBBER

(*b*) American Air Filter.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) Same as (e) above (scrubbers).

400-10490-340-70

MOHAVE PLANT SCRUBBER

(*b*) Stearns Roger.
(*c*) T. White.
(*d*) Experimental; design.
(*e*) Same as (e) above (scrubbers).
(*f*) Study complete. Report submitted to client.

400-10491-870-73

BELL STATION THERMAL MODEL STUDY

(*b*) New York State Electric and Gas Corporation.
(*d*) Experimental, for design purposes.
(*e*) A thermal hydraulic model to establish the conceptual design of the condenser cooling water arrangements for the Bell Nuclear Generating Station proposed for construction on the eastern shore of Cayuga Lake near the existing Milliken Coal-Fired Generating Station.
(*f*) Study complete, report submitted to client.
(*g*) Once the basic arrangement of the discharge structures was established, performance was evaluated under a complete range of temperature, level and current conditions. It was found that the selected arrangement met the modified discharge criteria established.

400-10492-840-87

YAQUE DEL NORTE CANAL INTAKE

(*b*) Dominican Republic.
(*d*) Experimental, for design purposes.
(*e*) Hydraulic model study of a diversion control structure for an irrigation canal intake.
(*f*) Study complete, report submitted to client.
(*g*) The maximum discharge capacity of the structures predicted by the model study was 2,200 m^3/s at a headpond elevation of 152 m. No subatmospheric pressures are expected at any of the overall structures. The safety of the weir and sluiceway will not be affected by erosion if recommended protection measures are employed. Effective removal of sediments deposited in the approach to the canal intake will be possible with sluiceway discharges of 125 m^3/s or more.

400-10493-350-75

GULL ISLAND DIVERSION TUNNEL MODEL STUDY

(*b*) Lower Churchill Consultants.
(*d*) Experimental, for design purposes.
(*e*) A study of the hydraulic losses in the 55 foot twin diversion tunnels scheduled for construction as part of the Gull Island project.
(*f*) Study complete, report submitted to client.
(*g*) With outlet modifications, the diversion tunnel scheme performs as intended and is satisfactory in hydraulic terms. The upstream cofferdam must be designed for a maximum water level of 220 feet elevation to accommodate a discharge of 210,000 cfs. To prevent severe scour of the riverbed downstream of the outlet, the outlet must be widened and deepened, and invert sills added. Due to high velocities during partial gate operation, the first 250 feet of the tunnels should be lined. To prevent bank erosion, riprap will be required on the north and south banks in the inlet approach area and on the north bank of the outlet.

400-10494-350-75

GULL ISLAND SPILLWAY MODEL STUDY

(*b*) Lower Churchill Consultants.
(*d*) Experimental, for design purposes.
(*e*) A spillway model study to rate the spillway and to study the hydraulics of the approach channel, particularly energy dissipation.
(*f*) Study complete, report submitted to client.
(*g*) The approach and outlet channels can be altered and still provide satisfactory hydraulic performance while reducing the total volume of rock excavation by 3.5 million cubic yards. The spillway structure, as designed, cannot pass the maximum probable flood without exceeding the maximum head pond level. Alternate spillway crest profiles were recommended and model testing of the selected profile will be required. A converging chute, reducing the spillway width to 250 feet at the flip bucket crest can be used as part of the spillway to reduce excavation and mass concrete costs.

400-10495-350-75

GULL ISLAND RIVER CLOSURE MODEL STUDY

(*b*) Lower Chruchill Consultants.
(*d*) Experimental, for design purposes.
(*e*) To study the sequence of construction of closure dykes to effect diversion of the Churchill River at Gull Island.
(*f*) Study complete, report submitted to client.
(*g*) The erosion potential of the natural riverbed is the most restrictive feature of the proposed closure. The four dykes should be constructed simultaneously so that the head loss across each is equal until the river is at least 90 percent closed. Phase 1 construction must be limited to 15-20 percent closure in order to pass the design flood of 210,000 cfs without severe bed erosion. Final closure of the river can be accomplished without problems at a discharge of 50,000 cfs.

400-10496-350-87

KPONG DIVERSION MODEL

(*b*) Volta River Authority.
(*d*) Experimental, for design purposes.
(*e*) Brief model study to verify the hydraulic adequacy of the proposed Stage 1 diversion arrangement, including head losses, local velocities in areas requiring erosion protection and excavated diversion channel geometry.

400-10497-350-87

KPONG SPILLWAY MODEL

(*b*) Volta River Authority.
(*d*) Experimental, for design purposes.
(*e*) A 1:50 scale hydraulic model was constructed to rate the spillway, to examine the approach flow conditions, and to establish operating constraints with regard to control of the hydraulic jump on the spillway system.
(*f*) Study complete, report submitted to client.
(*g*) As a result of an initial series of model tests, the original spillway cross section was modified to increase the discharge capacity of the structure. The modified spillway arrangement can pass the design flood of 20,670 m^3/s at the specified maximum head pond level of 17.7 m. Special gate operating procedures are necessary to prevent the hydraulic jump from either impinging on the back of the

254-330 O - 78 - 18

gates or sweeping off the apron. The spillway and powerhouse can discharge simultaneously without causing adverse hydraulic effects on the operation of either.

400-10498-340-75

LINGAN POINT INTAKE MODEL

(*b*) Albery, Pullerits, Dickson and Associates Limited.
(*d*) Experimental, for design purposes.
(*e*) A study of the influence of the intake on flow patterns in the Bridgeport Channel, Nova Scotia. The study also considered the potential for siltation of the intake.
(*f*) Study complete, report submitted to client.
(*g*) The construction of the proposed cooling water intake will not appreciably alter the flow patterns during either flood or ebb tides. The large exterior excavation and the unexcavated areas within the ice boom, as initially proposed, had a tendency to collect sediment and resulted in appreciable sediment inflow into the cooling water channel.

400-10499-300-90

CAPITAL CITY WEIR

(*b*) Alberta Department of Environment.
(*d*) Experimental, for design purposes.
(*e*) The project was concerned with the feasibility of constructing a low-gated barrage across the North Saskatchewan River at Edmonton. The pond created was to be used for recreation. To avoid flooding low-lying residential communities upstream, control of maximum water levels during spring flood was critical, while the low head available across the structure limited discharge capacity. A hydraulic model was commissioned to aid in the sizing, design and rating of the fish-belly gates. The model comprised two of the six gates, contained in a glass-walled flume, with flow control and water level measuring devices. The model was constructed of plexiglas, at a scale of 1:30, and employed a mobile bed of 2 mm sand for erosion studies.
(*f*) Suspended.

400-10500-340-75

FORKED RIVER CONDENSER MODEL

(*b*) Burns and Roe Incorporated.
(*c*) Mr. D. Mayer, Acres American Incorporated, Consulting Engineers, Liberty Bank Building, Main at Court, Buffalo, New York 14202.
(*d*) Experimental, for design purposes.
(*e*) The model was designed to examine flow distribution among three condensers in a cooling water system for a thermal electric generating station.
(*f*) Study complete, report submitted to client.
(*g*) Results indicated that the design was adequate.

400-10501-340-75

PERRY SUPPRESSION POOL

(*b*) Gilbert and Associates Incorporated.
(*c*) Mr. D. Mayer, Acres American Incorporated, Consulting Engineers, Liberty Bank Building, Main at Court, Buffalo, New York 14202.
(*d*) Experimental, for design purposes.
(*e*) The safety outlets for steam water pressure relief valves were located in the bottom of the suppression pool. Velocities and water temperatures were taken to determine the effects of cooling water injected through a jet in the pool.
(*f*) Study complete, report submitted to client.
(*g*) Results indicated that the design was adequate.

ALBERTA RESEARCH COUNCIL, TRANSPORTATION AND SURFACE WATER ENGINEERING DIVISION, 303 Civil-Electrical Building, University of Alberta, Edmonton, Alberta, Canada, T6G 2G7. Dr. S. Beltaos, Research Officer. (Note: The Council coordinates the Alberta Cooperative Research Program in Transportation and Surface Water Engineering. Major participants in this program, in addition to Council, are the Department of Civil Engineering, University of Alberta and two Provincial Government Departments–Alberta Environment and Alberta Transportation.)

401-07886-370-96

ICE FORCES ON BRIDGE PIERS

(*b*) Alberta Transportation.
(*d*) Field investigation; applied research.
(*e*) Measurement of dynamic forces during spring break-up on two special piers in different rivers.
(*g*) Measurements over ten seasons have produced maximum instantaneous apparent pressures of up to 350 psi on a vertical cylindrical pier and up to 170 psi on a pier inclined at 23° to the vertical. It has become evident that use of an apparent pressure on an inclined pier is not appropriate and an alternative has been formulated. A limited evaluation of the dynamic response characteristics of one of the piers suggested that instantaneous peak loads should be considered if designing on an "elastic" basis.

401-10761-300-96

ICE THICKNESS DOCUMENTATION

(*b*) Alberta Transportation, Alberta Environment.
(*d*) Field; applied research.
(*e*) Ice thickness measurements are being carried out at selected sites in an effort to determine ice thicknesses which can be generated by different processes in a river such as clear ice, snow ice, aufeis and hummocked ice and frozen frazil ice formation. Such information is required for the design for ice loads on bridge piers.
(*g*) Initial results indicate that ice flows much thicker than "usual" can result at breakup from the latter three processes. The possibility of such formations occurring upstream of a bridge site must be assessed during design.

401-10762-300-96

SPRING BREAKUP OBSERVATIONS

(*b*) Alberta Environment, Alberta Transportation.
(*d*) Field, analytical; applied research.
(*e*) Ice breakup observations at selected bridge locations in Alberta. Emphasis on action of ice on bridge piers and documentation of ice jam characteristics. Pre- and post-breakup measurement of ice thickness, type and strength.
(*g*) Documentation of several ice jams; yearly record of breakup at selected locations.
(*h*) **Preliminary Observations of Spring Ice Jams in Alberta,** R. Gerard, *Proc. 3rd Intl. Symp. Ice Problems*, Hanover, N. H., USA, Aug. 1975.
1977 Breakup and Subsequent Ice Jam at Fort McMurray, P. F. Doyle, Transportation and Surface Water Engrg. Div., Alberta Research Council, *Internal Rept. SWE/77/1*, June 1977.

401-10763-350-00

HYDRAULICS OF RIVER STRUCTURES

(*b*) Alberta Transportation, Alberta Environment.
(*d*) Field, experimental, analytical; applied research.
(*e*) Field measurements of flow and scour are made at bridges and river training works. Laboratory experiments on scour at an abutment have been started.
(*g*) Data have been collected at several sites during floods over past years but have yet to be analyzed.

401-10764-350-96

RIVER MORPHOLOGY

(*b*) Alberta Transportation, Alberta Environment.
(*d*) Field, analytical; applied research.

(*e*) Scour and channel shift are evaluated in various river types under different flow conditions to determine maximum depths of scour and channel shift for use in design of bridge piers, pipeline crossings, etc.
(*g*) Data have been obtained in a number of rivers over a period of several years, and some analysis has been done.
(*h*) **Hydraulic and Morphologic Characteristics of Athabasca River near Fort Assiniboine,** C. R. Neill, *Rept. REH/73/3*, Alberta Cooperative Research Program, 1973 (reports may be obtained from the above address).

401-10765-200-96

MIXING PROCESSES IN NATURAL STREAMS

(*b*) Alberta Environment.
(*d*) Field, analytical; applied research.
(*e*) Tracer tests in representative river types of Alberta for evaluating transverse and longitudinal mixing characteristics under both open-water and ice-covered conditions. Development of analytical and numerical techniques for engineering predictions.
(*g*) Transverse mixing coefficients have been evaluated at four river reaches. Longitudinal dispersion tests have been performed at two of these sites. A method has been developed for evaluating transverse mixing coefficients from slug-injection tests, based on the behaviour of time-integrals of unsteady concentration distributions. Such tests are occasionally preferable to the commonly employed, constant-rate injection tests. An explicit numerical algorithm, free of numerical diffusion, is being developed for simulating two-dimensional, time-dependent mixing in rivers. Preliminary comparisons with pertinent published data were satisfactory.
The applicability of the conventional longitudinal dispersion theory to natural streams has been questioned recently. An alternative solution, using a time-variable dispersion coefficient, was obtained and shown to agree with some field data. However, a recent field test indicated dispersive behaviour that could not be adequately described by either of these approaches. The possibility of developing a more general theory and the role of rivers' lack of prismaticity are under study.
(*h*) **Transverse Mixing in an Ice-Covered River,** J. E. O. Engmann, R. Kellerhals, *Water Resources Research* **10,** 4, pp. 775-784, Aug. 1974.
A Theory of Longitudinal Dispersion, S. Beltaos, Highway and River Engrg. Div., Alberta Research Council, *Internal Rept. REH/74/2*, 1974.
Evaluation of Transverse Mixing Coefficients from Slug Tests, S. Beltaos, *J. Hydraulic Research* **13,** 4, pp. 351-360, 1975.
Longitudinal Dispersion in a Natural Stream: Lesser Slave River, Alberta, S. Beltaos, T. J. Day, Transportation and Surface Water Engrg. Div., Alberta Research Council, *Internal Rept. REH/76/1*, 1976.

401-10766-300-96

FIELD INVESTIGATION OF A FRAZIL ICE HANGING DAM

(*b*) Alberta Environment, Alberta Transportation.
(*d*) Field; applied research.
(*e*) A large accumulation of frazil ice under the ice cover was detected during the 1974-75 winter season in the Smoky River some 40 km above its confluence with Peace River. Field investigations are in progress to elucidate the mechancis of formation and spring breakup, to evaluate effects on spring breakup in the Smoky and Peace Rivers and to assess the possible action against hydraulic structures of such frazil ice accumulations.
(*g*) Measurements revealed a local depression of the river bed with a maximum depth of 17 m below winter water levels, located immediately downstream of a rapids reach. This configuration is typical of conditions conducive to hanging dam formation. At full size this hanging dam is 300 m long and has a maximum thickness of 15 m. Consecutive spring breakup observations, beginning in 1975, suggest that the hanging dam causes ice jamming extending some 5 km upstream and a consequent local water level rise of about 4 m above pre-breakup levels.

401-10767-300-96

DOCUMENTATION AND PROBABILITY ANALYSIS OF PAST ICE BREAKUP WATER LEVELS

(*b*) Alberta Transportation, Alberta Environment.
(*d*) Field, analytical; applied research.
(*e*) Information on past breakup water levels at several sites in Alberta is being collected and a method of analysis developed to determine estimates of the probability distributions of annual peak breakup water levels at these sites. Such information is required in the design for ice action on bridge piers, and in assessing flood frequencies at locations prone to ice jams.
(*g*) A method of analyzing such historical data has been developed. Its application to information collected at one site has shown that the flood frequency curve is dominated by ice breakup water levels (i.e. ice jams) and not by summer flood water levels.
(*h*) **Probability Analysis of Historical Data on Ice Jam Floods,** R. Gerard, E. W. Karpuk, paper in preparation.

401-10768-310-96

REGIONAL ANALYSIS OF NORTHERN ALBERTA

(*b*) Alberta Transportation, Alberta Environment.
(*d*) Field, analytical; applied research.
(*e*) Hydrometric records for some 60 catchments in Northern Alberta are being analyzed to determine the snowmelt flood and rain flood for each year of record. The difference in these flood populations is to be assessed and indices of the populations related (i) to catchment characteristics, and (ii) for an index flood of the combined population, to channel geometry, using weighted regression analysis.
(*g*) Initial analysis indicates that snowmelt and rainfall floods do form distinct populations. The use of weighted regression has allowed the inclusion of very short records in the analysis and explicit consideration of interstation correlation associated with both genuine and "lack of fit" errors. The separate regressions on catchment characteristics and on channel geometry allow two almost independent estimates of an index flood for an ungauged catchment.

401-10769-310-96

PEAK RUNOFF FROM SMALL CATCHMENTS

(*b*) Alberta Transportation, Alberta Environment.
(*d*) Field investigation, analytical; applied research.
(*e*) Monitoring of peak runoff due to snowmelt and rainfall at 43 culvert sites in north-central Alberta. Investigation of culvert behaviour and confirmation of synthetic rating curves for these culverts under various flow conditions.
(*g*) Three years of snowmelt and rainfall runoff peak data on 43 small basins is presently being analyzed.

401-10770-830-96

SEDIMENT YIELD

(*b*) In cooperation with Department of Geography, University of Alberta, for Alberta Environment and Alberta Transportation.
(*d*) Field investigation; applied research; thesis.
(*e*) Several investigations by Department of Geography are being partially supported by the Cooperative Program. (i) Measurement of precipitation, runoff, erosion and sediment yield for a small catchment in the Red Deer River badlands and concurrent measurements of the actual rate of erosion at various locations in the catchment. The objective is to determine sediment yield, delivery ratio and rainfall-runoff relations for this extreme environment. (ii) Intermittent sampling for suspended and dissolved solids at approximately 50 streamgauging stations during significant runoff events. An attempt was made to estimate approximate sediment yields on the basis of rating and flow duration curves, and to relate them to geographic factors.

(*f*) (i) Active; (ii) completed.
(*h*) **Sediment Yields from Intermediate Sized Stream Basins in Southern Alberta,** H. J. McPherson, *J. Hydrology* **25,** pp. 243-257, 1975.
Soil Erodibility and Erosion in Part of the Bow River Basin, Alberta, S. H. Luk, *Ph.D. Thesis*, Dept. of Geography, Univ. Alberta, Edmonton, Canada, 1975.
Rainfall Erosion of Some Alberta Soils; A Laboratory Simulation Study, S. H. Luk, *Catena* **3,** 3/4, pp. 295-305, Mar. 1977.

UNIVERSITY OF ALBERTA, Department of Civil Engineering, Edmonton T6G 2G7, Alberta, Canada. Dr. N. Rajaratnam, Professor of Civil Engineering.

402-06630-300-90

ALBERTAN COOPERATIVE STUDIES OF RIVER REGIME

(*b*) University on NRC Grant.
(*c*) Dr. T. Blench.
(*d*) Basic and applied research.
(*e*) To aid the development of a formal quantitative inductive science of the self-adjustment of channels that form at least part of their boundaries in sediment. Steps are to collect and assess data; analyze and coordinate them in terms of an adequate "statement of case"; reduce the results to readily intelligible form, usually graphical; publicize the data, the results and their applications; and cooperate with other agencies.
(*g*) Publication with or by cooperating agencies has expanded since last report. Major coordinations of tabulated, graphed and discussed data are in Refs. 1 (rivers), 2 (flumes), 7 (all channels). A summary of major results and opinions in extension and description of Ref. 7 is in Ref. 8.
(*h*) **Hydraulic and Geomorphic Characteristics of Rivers in Alberta,** R. Kellerhals, C. R. Neill, D. I. Bray, (*Alberta Govt. Publication*) Alberta Research Council, 11315–87 Avenue, Edmonton, Alberta, 1972.
A Critical Review of Sediment Transport Experiments, R. H. Cooper, A. W. Peterson, T. Blench, *J. Hydraulics Div., Proc. ASCE* **98,** HY5, *Paper 8873*, pp. 827-843, May 1972.
Regime Problems of Rivers Formed in Sediment, T. Blench, Chapter 5 of *River Mechanics III*, Shen, Dept. of Civil Engrg., Colorado State Univ., 1973.
Comprehensive Graphs of Regime Data, T. Blench, A. W. Peterson, R. H. Cooper, *Research Symp. on River Mechanics*, Bangkok, Thailand, Jan. 9-12, 1973.
General Report on River Bed Form, T. Blench, *Ibid*, 1973.
Factors Controlling Size, Form and Slope of Stream Channels, T. Blench, *Proc. 9th Hydrology Symp.*, Natl. Res. Council, May 1973, Queen's Printer, Ottawa, 1973.
Regime Data, Volume I, Flume Data and Regime Basics, T. Blench, D. B. Simons, Commissioned by Intl. Comm. on Irrigation and Drainage, 48th Nyaya Marg, Chanakyapuri, New Delhi–21, India, 1974.
Graphic Coordination of Mobile-Bed Channel Data, T. Blench, R. H. Cooper, A. W. Peterson, *Hydrology Review*, Indian Natl. Comm. IHD/IHP, Council of Scientifc and Industrial Research, Rafi Marg, New Delhi 1-110001, India, Oct. 1975.
Observations of Natural and Man-Made River Spurs, T. Blench, V. J. Galay, E. K. Yaremko, *3rd Ann. Symp. of Waterways, Harbors and Coastal Engrg. Div., ASCE*, Aug. 10-12, 1976.

402-07836-220-00

FLOW IN ALLUVIAL CHANNELS

(*c*) A. W. Peterson, Professor.
(*d*) Experimental studies of sediment transport in open channels and analysis of world data.
(*e*) The behavior of flow in alluvial channels is being studied by analyzing the majority of the available experimental flume data.
(*h*) **Universal Flow Diagram for Mobile Boundary Channels,** A. W. Peterson, *Canadian J. Civil Engrg.*, 1975.
Design of Mobile Boundary Channels, A. W. Peterson, *Proc. Natl. Symp. on Urban Hydrology and Sediment Control*, Lexington, Ky., 1975.
Analysis of Hydraulic Resistance for Mobile Bed Channels, M. Michiue, A. W. Peterson, *Bull. Disaster Prevention Research Inst.* **25,** Kyoto Univ., Sept. 1975.
Coordination of Mobile Bed Channel Data, T. Blench, R. H. Cooper, A. W. Peterson, (updated) presented *IUTAM Mtg.*, Aug. 1976, Amsterdam.

402-09497-060-90

THERMAL DISCHARGES

(*b*) NRC of Canada.
(*d*) Basic research, experimental and analytical.
(*e*) Understand and predict the behaviour of thermal discharges in lakes and rivers.
(*g*) Experiments were performed with bluff buoyant surface jets for moderate and large Richardson numbers and the results were correlated with our earlier theoretical analysis. These studies were also extended to include the effects of an ambient current.
(*h*) **An Experimental Study of Bluff Buoyant Turbulent Surface Jets,** B. B. L. Pande, N. Rajaratnam, *J. Hydraulic Res.*, Delft, 1977.
An Experimental Study of Heated Surface Discharges into Ambients with Cross-Currents, V. Chiu, *M.Sc. Thesis*, 1976.

402-09499-220-90

EROSION BY JETS

(*b*) National Research Council of Canada.
(*d*) Basic research; experimental.
(*e*) Study the erosion produced by fairly simple flows with the idea of advancing our understanding of the erosion in practical situations.
(*g*) It has been found that for circular wall jets as well as for impinging circular jets, the characteristic depth of erosion first increases linearly with log time and later approaches an asymptotic value. Using dimensional analysis and the experimental results, it has been possible to predict the prominent features of the erosion process.
(*h*) **Erosion by Circular Turbulent Wall Jets,** N. Rajaratnam, B. Berry, *J. Hyd. Research*, Delft, 1977.
Erosion by Impinging Circular Turbulent Jets, N. Rajaratnam, S. Beltaos, *Proc. ASCE, J. of Hydraulics Div.*, (in press).

402-09500-440-90

SIMULATION OF LAKE LEVELS IN THE COOKING LAKE MORAINE

(*b*) Inland Waters and Department of Environment, Alberta.
(*c*) Dr. J. P. Verschuren.
(*d*) Theoretical, applied research for M.Sc.
(*e*) Monthly lake levels for a period of 500 years were estimated by developing a water balance model from historical meteorological data, physical characteristics of the basin and lake level records of Cooking Lake. A long record of meteorological data was generated using Monte Carlo methods.
(*f*) Completed.
(*g*) Lake level fluctuations can be explained entirely by variability in climate without considering land use changes resulting from changes in the agricultural use of the land.
(*h*) **Simulation of Lake Levels,** D. Crawford, *M.Sc. Thesis*.

402-09501-310-90

FLOOD PREDICTION ROSS RIVER AND STUART RIVER, YUKON

(*b*) Department of Indian Affairs and Northern Development.
(*c*) Dr. J. P. Verschuren.
(*d*) Applied research.

(*e*) Development of a predictive model for flooding in communities near the Ross River and the Stuart River as a function of climatic variables and preceding discharges so that an early flood warning system can be established.
(*f*) Completed.
(*g*) Estimates of discharge can be made, one to four days in advance, depending on the lead time of the meteorological forecasts.
(*h*) **Spring Flood Forecasting for Mayo and Ross Rivers, Yukon Territory,** J. P. Verschuren, D. Crawford, Dept. Civil Engrg., Apr. 1976.

402-10282-300-90

ANALYTICAL RIVER MECHANICS

(*b*) National Research Council Grant.
(*c*) Dr. Gary Parker.
(*d*) Theoretical; basic, some applied aspects.
(*e*) Analytical techniques are being used to formulate and treat a variety of features of flow-induced fluvial morphology. The work naturally divides into two aspects: (a) the interaction of flow and sediment in channels with imposed widths, and (b) the formation of river banks and maintenance of channel width. Included in the former are treatments of antidune formation, incipient meandering and braiding, and channel degradation and aggradation. In the latter category are two forthcoming treatments of self-formed banks in gravel, and sand-silt rivers.
(*g*) Some progress has been made toward a treatment of bed load from the point of view of continuum mechanics. A unifying format for load and resistance relations for alluvial rivers has been determined. Criteria for the occurrence of meandering and braiding have been derived. A model has been presented for determining self-formed channel geometry and rational regime relations for rivers.
(*h*) **Sediment Inertia as a Cause of River Antidunes,** G. Parker, *J. Hydraulics Div., ASCE* **101,** HY2, pp. 211-221, Feb. 1975.
Meandering of Supraglacial Melt Streams, G. Parker, *Water Res. Research* **11,** 5, pp. 551-552, Aug. 1975.
Modeling of Meandering and Braiding in Rivers, G. Parker, A. G. Anderson, *Proc. ASCE, Modeling, 1975 Symp.*, pp. 575-591, Sept. 3-5, 1975.
On the Cause and Characteristic Scales of Meandering and Braiding in Rivers, G. Parker, *J. Fluid Mech.* **76,** 3, pp. 457-480, Aug. 11, 1976.
Detrimental Effects of River Channelization, G. Parker, D. Andres, *Proc. ASCE Rivers, 1976 Symp.*, pp. 1248-1266, Aug. 10-12, 1976.
Self-Formed Straight Rivers with Stable Banks and Mobile Bed in Coarse and Fine Noncohesive Material, G. Parker, Dept. Civil Engrg., Univ. of Alberta, June 1977.

402-10283-810-00

SOIL MOISTURE INDICES AND SNOWFALL CORRELATION TO SNOWMELT RUNOFF IN CENTRAL ALBERTA

(*c*) Dr. J. P. Verschuren, Civil Engineering.
(*d*) Applied research for M.Sc.
(*e*) The snowmelt runoff in the spring, not including the runoff due to spring rain, was determined as a function of base flow storage, antecedent precipitation and a basin recharge coefficient at time of freeze-up in the previous fall for 5 basins in the Alberta plains between 52° Lat. and 56° Lat.
(*f*) Completed.
(*g*) Curves are available to compute the expected runoff based on the snowfall during the winter and the parameters mentioned under "e."
(*h*) **Soil Moisture, Snow and Snowmelt Runoff Correlation,** T. P. S. Sandhu, *M.Sc. Thesis*.

402-10284-410-90

HYDRAULICS OF GROYNES

(*b*) NRC of Canada.
(*c*) N. Rajaratnam, Professor.
(*d*) Basic and experimental.
(*e*) Understand the nature of flow around groin-like obstacles and to develop a method of predicting erosion near such structures.
(*g*) The results are being analysed at this time.

402-10285-810-90

A SIMULATION MODEL TO EVALUATE THE EFFECT OF LOGGING ON THE RATE AND TIME DISTRIBUTION OF RUNOFF

(*b*) NRC.
(*c*) Dr. J. P. Verschuren, Civil Engineering.
(*d*) Theoretical, applied research, Ph.D. thesis.
(*e*) By dividing the watershed into modules, the water balance of each module can be determined. The outflow from one module will be part of the inflow into the module down slope.

402-10286-810-90

DISPOSITION OF WATER IN FOREST SOILS

(*b*) Canadian Forestry Service.
(*c*) Dr. J. P. Verschuren, Civil Engineering.
(*d*) Theoretical, basic research, Ph.D. thesis.
(*e*) Evaluate saturated and/or unsaturated transient flow through nonhomogeneous, anisotropic porous media, i.e., through typical forest soils, in response to the forces of drainage, transportation and evaporation.

UNIVERSITY OF ALBERTA, Department of Mechanical Engineering, Edmonton, Alberta, Canada T6G 2E1. Dr. R. R. Gilpin, Associate Professor.

403-10221-190-90

ABLATION OF ICE BY WATER JET

(*b*) National Research Council of Canada.
(*d*) Experimental and theoretical basic research, M.Sc. thesis.
(*e*) Studies have been made of the rate of melting of a hole in a block of ice by an impinging water jet. A numerical simulation technique has been devised which predicts the rate of penetration of the jet into the ice as well as the evolution of the shape of the hole melted. These results are compared with experimental measurements on the same phenomenon.
(*f*) Completed.
(*g*) It was found that the shape of the hole melted could be predicted near the stagnation point. Also, the rate of penetration was predicted accurately for all conditions examined.
(*h*) **The Ablation of Ice by a Water Jet,** R. R. Gilpin, *Trans. Can. Soc. of Mechanical Eng.* **2,** 2, pp. 91-96, 1973.
Laminar Jet Impingement Heat Transfer Including the Effects of Melting, A. W. Lipsett, R. R. Gilpin, *Intl. J. Heat and Mass Transfer*, in press.

403-10222-140-90

RADIATIVE HEATING OF ICE AND WATER

(*b*) National Research Council of Canada.
(*d*) Experimental and theoretical applied research, M.Sc. thesis.
(*e*) Studies were made to determine the distribution of radiative heating produced in ice and water layers that are exposed to radiative energy fluxes. A determination of the effects of scattering in the ice and of the type of light source on the distribution of the heating produced were the two main objectives of the ice study. For a water layer the effect of the radiative heating on natural convection in the layer was also examined.
(*f*) Completed.
(*g*) It was found that the heating produced by a radiation source in either water or ice is best modeled by a power law relationship rather than the normal Bouquer-Sanbert exponential law. This occurs because of the strong

wavelength dependence of the absorption coefficients of ice and water. For thin ice layers scattering in the ice was found to actually increase the rate of heating produced in the ice. This effect was produced by a trapping of the radiation due to scattering in the ice. For a water layer radiation absorption can produce a thermal instability and subsequent natural convection.

(*h*) **Heat Transfer in a Horizontal Water Layer with Radiative Heating,** R. R. Gilpin, *Trans. Can. Soc. of Mechanical Eng.* **1**, 4, pp. 213-218, 1972.
Radiative Heating in Ice, R. R. Gilpin, R. B. Robertson, B. Singh, *J. Heat and Mass Transfer*, May 1977, in press.

403-10223-010-90

THERMAL STABILITY OF A BLASIUS FLOW OVER A FLAT PLATE

(*b*) National Research Council of Canada.
(*c*) Dr. R. R. Gilpin or Dr. K. C. Cheng.
(*d*) Experimental research on basic phenomena.
(*e*) Studies are being made of the conditions for the onset of instability in a laminar boundary layer over a flat plate due to thermal effects. Heat transfer in the past critical region has also been measured. Other conditions that are being examined are the instability in the presence of ice growth on the plate and the effect of the maximum density of water at 4 °C.
(*g*) Results show that the transition to turbulent flow in a laminar boundary layer can be induced by thermal instability as well as by hydrodynamic effects. The effects of this thermal instability on heat transfer rates and also friction factors can be considerable.

403-10224-190-90

A STUDY OF THE PIPE FREEZING PROCESS

(*b*) National Research Council of Canada.
(*d*) Experimental applied research.
(*e*) Studies have been made of the formation of ice in a pipe containing stagnant water, that is, no through flow. These tests have been designed to determine the time that a pipe can stand in a sub-freezing environment and not become blocked by ice formation.
(*g*) It was found that dendritic ice formed as a result of supercooling in the pipe can cause a pipe blockage early in the freezing history of the pipe. Such a blockage would occur much sooner than a blockage due to the growth of a solid annulus of ice forming from the pipe wall. Since the latter form of ice is commonly assumed in calculations of the time required for a pipe blockage to occur, these calculations would appear to grossly overestimate the time during which a pipe can safely stand with no main flow through it.
(*h*) **Ice Formation in Pipes,** R. R. Gilpin, *Proc. 2nd Intl. Symp. on Cold Regions Engrg.*, Univ. of Alaska, Aug. 1976.
The Effects of Dendritic Ice Formation in Water Pipes, R. R. Gilpin, *Intl. J. Heat and Mass Transfer* **20,** in press.

UNIVERSITY OF BRITISH COLUMBIA, Department of Civil Engineering, Hydraulics Laboratory, Vancouver, B.C., V6T 1W5, Canada. Professor Sam Lipson, Department Head.

404-10225-630-90

INFLUENCE OF WATER HAMMER ON TURBINE GOVERNING

(*b*) National Research Council of Canada.
(*c*) Dr. E. Ruus.
(*d*) Theoretical; applied research, Doctoral thesis.
(*e*) The influence of water hammer on turbine governing is considered at present by evaluating the former using rigid water column theory. This gives reasonably good results for relatively slow and small changes in turbine output, i.e., where the water hammer effect is small. The aim of this study is to incorporate the water hammer analysis according to the elastic water column theory into the turbine governing analyses, which would then yield satisfactory results even for rapid changes in output of turbines served by long penstocks.

404-10226-630-00

INFLUENCE OF SPECIFIC SPEED ON PRESSURE SURGES CAUSED BY PUMP FAILURE IN PIPELINES WITHOUT ANY PROTECTIVE DEVICES

(*c*) Dr. E. Ruus.
(*d*) Theoretical; applied research.
(*e*) Maximum upsurges and downsurges are calculated and plotted in nondimensional form for a simple pump discharge line. Pipeline constant, the inertia of the motor and the pump, pipe wall friction and pump characteristics at specific speeds 1800, 3500, 7600 and 13500 are considered. The results can be used to determine the necessary pipe wall thickness.
(*g*) The specific speed has a relatively small influence on the maximum downsurge at the pump end of the pipeline; it has, however, a drastic influence on the maximum upsurge. A low specific speed pump yields the largest upsurge.

404-10227-340-90

MAXIMUM SURGES IN SIMPLE SURGE TANKS

(*b*) National Research Council of Canada.
(*c*) Dr. E. Ruus.
(*d*) Theoretical; applied research.
(*e*) Maximum upsurges and downsurges resulting from linear decreases or increases in turbine discharge, gate opening or power output are calculated for simple surge tanks. Tunnel friction and velocity head are considered. The results are plotted in nondimensional form against conduit friction and the time of closure or opening.
(*f*) Completed.
(*g*) Both friction and time of closure or opening reduce the upsurge and downsurge substantially.
(*h*) **Maximum Surges in Simple Surge Tanks,** E. Ruus, F. A. El-Fitiany, *Canadian J. Civil Engrg.* **4,** 1, pp. 40-46, 1977.

404-10228-210-90

WATER HAMMER IN PIPELINES WITH AIR CHAMBERS

(*b*) National Research Council of Canada.
(*c*) Dr. E. Ruus.
(*d*) Theoretical; applied research.
(*e*) Maximum upsurges and downsurges caused by pump failure are calculated and plotted in nondimensional form for a simple pump discharge line provided with an air chamber. Pipeline constant, air chamber parameter, pipe wall friction and orifice resistance are considered. The results can be used to determine the necessary volume of the air chamber.
(*f*) Completed.
(*g*) While the assumption of the rigid water column and the concentration of pipe friction at the pump end of the pipeline yield reasonably good results at the pump end, large errors in estimation of both upsurges and downsurges occur at the midpoint and particularly at the quarter point of the pipeline.
(*h*) **Charts for Water Hammer in Pipelines with Air Chambers,** E. Ruus, *Canadian, J. Civil Engrg.* **4,** 3, 1977.

404-10229-810-96

EFFECT OF URBANIZATION ON STORM RUNOFF

(*b*) British Columbia Water Resources Service.
(*c*) Dr. S. O. Russell.
(*d*) Applied research.
(*e*) Urbanization affects the response of a basin to storm rainfall. Rainfall and runoff are being measured from two adjacent basins–one from the university complex which can be considered as urban, and one from an adjacent completely undeveloped basin.

404-10230-370-90

CULVERT DESIGN STUDY

(*b*) National Research Council.
(*c*) Dr. S. O. Russell.
(*d*) Applied research.
(*e*) Culvert design depends on many uncertain factors. Decision theory is being used to determine an optimal design for a test case considering flow uncertainties, probable damage and culvert hydraulics.
(*h*) **Master's Thesis,** in preparation, P. Neudorf, 1977.

404-10231-350-96

USE OF FIBRE REINFORCED CONCRETE IN SMALL DROP STRUCTURES

(*b*) British Columbia Water Resources Service.
(*c*) Dr. S. O. Russell.
(*d*) Applied research.
(*e*) In British Columbia there are many very steep gravel and boulder creeks with a need for inexpensive drop structures. Fibre reinforced concrete has a tensile strength that can be counted upon. Its use for drop structures is being investigated.

404-10232-300-96

FLOOD PROBLEMS IN GRAVEL RIVERS

(*b*) B. C. Disaster Relief Fund.
(*c*) Dr. M. C. Quick.
(*d*) Applied research.
(*e*) Gravel rivers in flood frequently undergo drastic changes in their channel positions. Damaging flooding can result. The current research aim is to develop reasonable understanding of the necessary channel width and available sediment storage so that a gravel river can be kept stable within a predetermined channel.
(*g*) Sediment routing coupled with a hydrologic flow model has been developed.
(*h*) **Master's Thesis,** in preparation, D. McLean, 1977.

404-10233-300-90

INTERACTION OF SEDIMENT AND RIVER FLOWS

(*c*) Dr. M. C. Quick.
(*d*) Applied research.
(*e*) Sediment bedforms and river channel cross-section and planform are studied as a sediment-flow interaction.
(*g*) Meandering processes have been modeled numerically using vorticity concepts. Bedforms are being studied analytically and experimentally, the emphasis being a basic sediment and flow processes.
(*h*) **Mechanics of Streamflow Meandering,** M. C. Quick, *J. Hydraulics Div., ASCE* **100,** HY6, pp. 741-753, June 1974.

404-10234-810-96

FLOOD FORECASTING

(*b*) British Columbia Disaster Relief Fund.
(*c*) Dr. M. C. Quick, Professor.
(*d*) Applied research.
(*e*) Two sets of computer models, a watershed model and a channel/reservoir routing model have been developed. The present emphasis concerns interpretation of local meteorological data in terms of basin wide behaviour for mountainous catchments. Snowmelt is a major contribution to these floods.
(*g*) An improved method of snowmelt calculation from temperature data has been developed. Orographic precipitation influences have been modeled using a stability factor based on adiabatic lapse rates.
(*h*) **Daily and Seasonal Forecasting with a Water Budget Model,** M. C. Quick, A. Pipes, *Proc. Intl. Symp. on the Role of Snow and Ice in Hydrology*, UNESCO, WMO, and NRC, Canada, Banff, pp. 1017-1034, Sept. 1972.
Nonlinear Channel Routing by Computer, M. C. Quick, A. Pipes, *J. Hydraulics Div., ASCE* **101,** HY6, pp. 651-665, June 1975.
A Combined Snowmelt and Rainfall Runoff Model, M. C. Quick, A. Pipes, *Canadian J. Civil Engrg.* **3,** 3, pp. 449-460. Sept. 1976.
UBC Watershed Model, M. C. Quick, A. Pipes, *Hydrological Sciences Bulletin* **XXII,** 1, 3/1977.
UBC Watershed and Flow Manuals, M. C. Quick, A. Pipes, Dept. of Civil Engrg., UBC, 1976.

404-10235-630-00

OPTIMUM PUMP SUMP DESIGN

(*c*) Dr. M. C. Quick.
(*d*) Experimental and theoretical; applied research.
(*e*) A basic investigation of vortex behaviour coupled with a study of flow patterns in sump configurations is being made. Conclusions arising from these studies are being used to develop an optimum design procedure for pump sumps.
(*h*) **Efficiency of Air-Entraining Vortex Formation at a Water Intake,** M. C. Quick, *Proc. ASCE, J. Hydr. Div.,* **96,** HY7, pp. 1403-1416, July 1970.
Master's Thesis–A Study of Formation of Vortices in a Multiple Pump Sump, J. W. K. Spurr, 1970.

404-10236-400-90

SALINITY INTRUSION IN ESTUARIES

(*b*) National Research Council.
(*c*) Dr. M. C. Quick.
(*d*) Applied research.
(*e*) Computer modeling of dynamic salt wedge behaviour is related to a field program of data measurement.
(*f*) Completed.
(*g*) Salt-water intrusion in the Fraser River estuary was modeled numerically and compared with a field measurement program. The salt wedge was observed to have a highly dynamic behaviour and yet to retain its stratified character. The main physical and computational problems studied were the interfacial stress term; the necessary boundary conditions at the river mouth; and the computational stability.
(*h*) **Salinity Intrusion in the Fraser River Estuary,** *Ph.D. Thesis*, D. O. Hodgins, Dept. of Civil Engrg., UBC, 1974.
A Numerical Model of Stratified Estuary Flows, M. C. Quick, D. O. Hodgins, T. R. Osborn, *J. Waterways, Harbour and Coastal Engrg. Div., ASCE* **103,** WW1, Jan. 1977.

CANADA CENTRE FOR INLAND WATERS, Hydraulics Research Division, 867 Lakeshore Road, Burlington, Ontario, L7R 4A6, Canada. T. M. Dick, Division Chief.

405-09507-300-00

DISPERSION IN MEANDERING CHANNELS

(*c*) Dr. B. G. Krishnappan and Dr. Y. L. Lau.
(*d*) Experimental, theoretical; applied research.
(*e*) Project is aimed at measuring the transverse dispersion coefficient in laboratory meandering channels for various geometrical configurations. Results of this project would reveal the effects of the secondary currents caused by the meander on the dispersion process.
(*f*) Completed.
(*g*) Dispersion coefficients were measured in the laboratory in meandering channels with varying bottom topography. Different assumptions for the variation of the dispersion coefficient were tested but none exhibited superiority over the others. A numerical scheme was developed to calculate the concentration distribution in a meandering channel.
(*h*) **Transverse Mixing in Meandering Channels with Varying Bottom Topography,** B. G. Krishnappan, Y. L. Lau, *Hydraulics Res. Div. Rept.*, CCIW, Burlington, Ontario, Nov. 1976.

405-09509-200-00

TRANSVERSE DIFFUSION IN OPEN-CHANNEL FLOW

(*c*) Dr. Y. L. Lau.
(*d*) Experimental, basic research.
(*e*) Investigate the dependence of the diffusion coefficient on the different flow variables.
(*g*) The dependence of the dispersion coefficient on friction factor and width-depth ratio in rectangular channels has been investigated. Effect of a cross-section shape and variation of dispersion coefficient across the channel are being studied.
(*h*) **Effect of Friction Factor and Aspect Ratio on Transverse Dispersion in Open-Channels,** Y. L. Lau, B. G. Krishnappan, *Hydraulics Res. Div. Rept.*, CCIW, Burlington, Ontario, 1976.

405-09510-870-00

CRITERIA FOR OIL SLICK CONTAINMENT IN FLOWING WATER USING BOOMS

(*c*) Dr. Y. L. Lau.
(*d*) Experimental, applied research.
(*e*) Obtain criteria for oil spill containment and to produce realistic estimates of volume of oil containable under given flow conditions, conditions under which no containment is possible and feasibility of diverting oil slicks using booms under such conditions.
(*f*) Suspended.
(*g*) Experiments have been completed.
(*h*) **A Review of the Dynamics of Contained Oil Slicks,** Y. L. Lau, S. A. Kirchhefer, Hydraulics Div., CCIW. Unpublished report.

405-09511-810-00

MODELING OF URBAN RUNOFF

(*c*) Mr. J. Marsalek.
(*d*) Theoretical and field investigation.
(*e*) Selected urban runoff models are evaluated by comparing simulated runoff hydrographs and pollutographs with field observations.
(*g*) Uncalibrated, deterministic urban runoff models such as the Road Research Laboratory Model (RRLM), Storm Water Management Model (SWMM and University of Cincinnati Urban Runoff Model (UCURM), reproduced fairly well runoff events observed on small urban catchments. On average, about 60 percent of the simulated runoff volumes and peak flows were within 20 percent of the observed values. When comparing the entire simulated and observed hydrographs, the SWMM simulations were marginally better than those produced by the RLL model, and both these models were found more accurate than the UCUR model.
(*h*) **Comparative Evaluation of Three Urban Runoff Models,** J. Marsalek, T. M. Dick, P. E. Wisner, W. G. Clarke, *Water Resour. Bull.* (*AWRA*) **11**, 2, Apr. 1975.
Review of Canadian Design Practice and Comparison of Urban Hydrologic Models, Canada-Ontario Agreement on Great Lakes Quality, *Res. Rept. No. 26*, Dept. of Environment, Ottawa, Oct. 1976.

405-09512-870-00

ENERGY LOSSES AT SEWER PIPE JUNCTIONS

(*c*) Mr. J. Marsalek.
(*d*) Experimental; applied research.
(*e*) Energy losses at sewer pipe junctions are determined experimentally for various geometrical configurations under free flow conditions.
(*g*) Report on straight-flow-through junctions is under preparation.

405-09513-420-00

WAVE ENERGY AT POINT PELEE, LAKE ERIE

(*c*) Dr. M. G. Skafel.
(*d*) Field investigation, theoretical; applied research.
(*e*) Offshore wave data were collected on both sides of the point. The longshore sediment transport rates were calculated and used to estimate the amount of erosion and/or accretion along the shoreline.
(*f*) Completed.
(*h*) **Longshore Sediment Transport at Point Pelee,** M. G. Skafel, Hydraulics Res. Div., CCIW Unpublished Report, 1975.

405-09515-300-00

FRICTION COEFFICIENT OF ICE COVERED RIVERS

(*c*) Dr. G. Tsang.
(*d*) Field, basic, applied.
(*e*) Study the friction coefficient of ice-covered rivers as compared with open water conditions.
(*f*) Temporarily suspended.
(*g*) Partly compiled.

405-09516-410-00

ICE PILING ON LAKE SHORES

(*c*) Dr. G. Tsang.
(*d*) Field, basic, applied.
(*e*) Study the cause and phenomena of ice piling on shores.
(*f*) Completed.
(*g*) Previous conclusions further confirmed. A field ice piling was filmed and the simultaneous meteorological data recorded.
(*h*) **A Field Study on Ice Piling on Shores and the Associated Hydro-Meteorological Parameters,** G. Tsang, *Proc. 3rd IAHR Symp. on Ice Problems*, Hanover, N.H., Aug. 1975.

405-09517-390-00

FORMATION OF FRAZIL ICE IN WATER WITH SURFACE WAVES

(*c*) Dr. G. Tsang.
(*d*) Theoretical, basic.
(*e*) Study the heat flux and the formation of ice in water when subject to sinusoidal surface waves of various amplitude and frequency.
(*f*) Temporarily suspended.
(*h*) **Conceptual Design of a Multi-Purpose Instrument for Winter Stream Metering,** G. Tsang, *Proc. Interdisciplinary Symp. Advanced Concepts and Techniques in the Study of Snow and Ice Resources*, National Acad. Sci., 1974.
Preliminary Investigation and Experimental Set-Up for the Study of Frazil Formations in Water with Surface Waves, G. Tsang, *Proc. Seminar Ice Thermal Regimes*, Laval University, Oct. 1974. Paper may be obtained through Division of Building Research, National Research Council, Ottawa.

405-10287-750-00

DISTORTED PHYSICAL MODELS

(*c*) Dr. Y. L. Lau.
(*d*) Experimental; applied research.
(*e*) The project is aimed at studying the effect of scale distortion on physical models used to study the dispersion of materials in open-channel flows.
(*g*) Experiments will begin shortly.

405-10288-710-00

TRACER MEASUREMENT OF RIVER EVAPORATION

(*c*) Dr. Y. L. Lau.
(*d*) Experimental, applied research.
(*e*) A method of measuring evaporation from rivers is required. This study investigates the feasibility of calculating the evaporation rate by measuring the loss of a radioactive tracer which is released in the flow.
(*f*) Completed.
(*g*) Laboratory experiments were conducted in which transfers of water vapour and tritium out of a body of water took place simultaneously. Conditions of wind as well as turbu-

lence in the water were varied. The mass transfer rate constants for the two species were compared. It was concluded that, for this method to be feasible, further work onto the effect of turbulence in the water on the tritium transfer rate is required.
(*h*) **Tracer Measurement of River Evaporation,** Y. L. Lau, *Inland Waters Directorate Scientific Series*, Ottawa, 1977.

405-10289-420-00

WAVE FORCES ON INSTRUMENT TOWERS

(*b*) Engineering Services Section, Department of Fisheries and the Environment, Canada Centre for Inland Waters.
(*c*) Mr. P. Engel.
(*d*) Operation, development.
(*e*) Provide our estimate of wave forces on lattice type, guyed instrument towers for research in the Great Lakes.
(*f*) Completed.
(*g*) Design forces due to waves on instrument towers of small effective diameter in lakes are developed using Stoke's Second Order Wave Theory. Consideration is given to the relative magnitude of inertial and drag forces indicating that the first is not significant for design conditions. The analysis shows that the total resultant force can be expressed entirely as a drag force.
For design purposes, dimensionless charts are developed which permit easy determination of the resultant force given the value of wave length and still water depth. These charts are prepared for horizontal and vertical forces. Considerations are also given to the force distribution along the length of the towers and the desirable distance for instrument platforms above the still water level.
Drag tests were conducted on three sections of lattice type towers of different geometry under steady state conditions in the towing tank of the Hydraulics Research Division at the Canada Centre for Inland Waters.
Wave forces on towers of the types tested and a tubular tower, were computed for conditions at the location of the Micro Met 1975 project in Lake Ontario. Toward this end a wave climate was established and a design wave of 20 feet with a period of 7 seconds, recommended for design purposes.
(*h*) **Wave Forces on Instrument Towers of Small, Effective Diameter,** P. Engel, *Hydraulics Research Div. Rept.*, Mar. 1975.

405-10290-700-00

CALIBRATION EQUATION FOR PRICE CURRENT METERS

(*c*) Mr. P. Engel.
(*d*) Applied research.
(*e*) Provide information on the effects of fluid properties on the Price current meter.
(*f*) Completed.
(*g*) A universal calibration curve has been developed using the theoretical and empirical methods. The analysis shows that for a meter of given rotor diameter and fixed frictional resistance, the rate of rotation of the meter rotor is dependent only on the speed of the fluid and the fluid density. It is further shown that changes in temperature and small changes in density as experienced when changing from fresh water to salt water, do not have a significant effect on measurement accuracy.
A practical form of the calibration equation states that the fluid velocity multiplied by the square root of fluid density is a function of the rotation rate times the square root of fluid density. Suggestions are made for applying the universal calibration equation to the calibrations of current meters in wind tunnels. The principles developed can be applied to other current meters used in oceanographic and lake surveys as well as anemometers used to measure wind velocities.
(*h*) **A Universal Calibration Equation for Price Meters and Similar Instruments,** P. Engel, Hydraulics Res. Div., *Inland Waters Directorate Scientific Series No. 65*, 1976.

405-10291-350-90

HYDRAULIC MODEL STUDY OF CONTROL STRUCTURES

(*b*) Water Planning and Management Branch, Department of Fisheries and the Environment.
(*c*) Mr. P. Engel.
(*d*) Applied research, design, development.
(*e*) Model studies conducted on a fixed crest weir and a gated control structure to develop rating curves, stilling basin and downstream channel protection.
(*f*) Completed.
(*g*) Study done in two separate reports.
Fixed Crest Weir–A model of a proposed weir for the Richelieu River was constructed and tested. Model scale was 1:9.83. The tests were conducted to obtain the stage-discharge relationship and to investigate if the control of the tailwater level will affect the discharge coefficient. It was found that the discharge coefficient was not affected for flows lower than about 40,000 ft^3/s. Two modifications to the toe of the weir were tested. Both showed significant reduction in scour of the river bed as compared with the original weir design. A horizontal extension of the weir is the recommended modification. The rip-rap protection was designed and tested and found to be stable for the weir with the recommended extension.
Gated Structure–A proposed gated structure for the Richelieu River was tested using a 1:12 scale hydraulic model. Discharge coefficients were obtained for various settings of the gate under both natural and controlled tailwater conditions. Observations of the flow indicated that the proposed stilling basin design may not be adequate. A revised design was proposed and tests showed that the flows leaving this basin were much less turbulent. Tests of rip-rap protection for the river downstream of the basin were made and the required rip-rap mixture is recommended.
(*h*) **Hydraulic Model Tests of the Proposed Weir for the Richelieu River at St. Jean, Quebec,** P. Engle, Y. L. Lau, *Hydraulics Research Div. Rept.*, CCIW, Mar. 1977.
Hydraulic Model Tests of the Proposed Gated Control Structure for the Richelieu River at St. Jean, Quebec, P. Engel, Y. L. Lau, *Hydraulics Res. Div. Rept.*, CCIW, Apr. 1977.

405-10292-220-00

HYDROGRAPHIC TECHNIQUE FOR BEDLOAD DISCHARGE

(*c*) Mr. P. Engel.
(*d*) Experimental.
(*e*) To establish the feasibility of and the criteria for the determination of bed load transport from spatial and temporal survey of bedform movement in large rivers.

405-10293-470-90

WHEATLEY HARBOUR MODEL STUDY

(*b*) Small Craft Harbours, Department of Fisheries and the Environement (Canada).
(*c*) Dr. M. G. Skafel.
(*d*) Experimental; design.
(*e*) A 1:60 scale model of Wheatley Harbour, Lake Erie, was constructed to evaluate different schemes for protecting the harbour entrance from storm waves out of the east and northeast.
(*f*) Completed.
(*h*) **Wheatley Harbour Model Study,** M. G. Skafel, Hydraulics Res. Div., CCIW Unpublished Report, 1977.

405-10294-410-00

LITTORAL DRIFT AND EROSION MODEL

(*c*) Dr. M. G. Skafel.
(*d*) Field, theoretical; applied research.

(*e*) Waves, currents and sediment transport will be measured on a sand beach to provide data for modeling sediment transport in the littoral zone. Model concepts will be developed.

405-10295-220-00

SEDIMENT TRANSPORT DUE TO WAVES AND CURRENTS

(*c*) Dr. M. G. Skafel and Dr. B. G. Krishnappan.
(*d*) Experimental; basic research.
(*e*) Measurements of sediment motion under waves with a superimposed unidirectional current will be made in a wave flume to quantify their interactions.

405-10296-300-00

MATHEMATICAL RIVER RESPONSE MODEL

(*c*) Dr. B. G. Krishnappan.
(*d*) Theoretical and field investigation; applied research.
(*e*) This study is aimed at developing a mathematical model which will predict the response of a river for various physical changes.
(*g*) The development of the model is completed. This model is being tested for laboratory and field conditions. This model solves the continuity equation for the sediment-water mixture and the momentum equation numerically, and corrects the solution at each step using the continuity equation for sediment.
(*h*) **Mathematical Modeling of Sediment-Laden Flows in Natural Streams**, B. G. Krishnappan, N. Snider, *Inland Waters Directorate Scientific Series No. 81* (in press).

405-10297-300-00

BASIC STUDY ON MEANDER FORMATION

(*c*) Dr. B. G. Krishnappan and Dr. T. M. Dick.
(*d*) Experimental; basic research.
(*e*) In spite of numerous studies carried out in the past, the basic mechanisms governing the formation of meanders are still not understood. This study is undertaken to systematically conduct experiments and gather basic data which could shed some light on these basic mechanisms.

405-10298-870-00

DEVELOPMENT OF AN ICE-OIL BOOM

(*c*) Dr. G. Tsang.
(*d*) Applied; development.
(*e*) The theoretical and later prototype development of a boom which can separate spilled oil and drifting ice floes in flowing water by deflecting the ice to one side while permitting the spilled oil to flow through the perforated openings to the ice-free area downstream, to be contained and collected by conventional means.
(*g*) Theoretical study showed that a timber boom which only needs anchoring at one point can be developed. The boom would be provided with fins and these can change the angle of the boom with the on-coming current by altering its rudder angle. An experimental boom is presently being constructed by the U.S. Coast Guard and will be tested later.

405-10299-700-00

DEVELOPMENT OF A FRAZIL ICE INSTRUMENT

(*c*) Dr. G. Tsang.
(*d*) Development.
(*e*) To develop an instrument which can measure the point concentration of frazil ice in water.
(*g*) An experimental instrument has been constructed and tested. This instrument showed that the concentration of frazil ice in water can be quantitatively measured by measuring the effect of ice on the resistivity and di-electrical constant of water. A manufacturable prototype instrument is presently being developed based on findings from the experimental instrument.
(*h*) **Development of an Experimental Frazil Ice Instrument**, G. Tsang, *Proc. 3rd Canadian Natl. Hydrotechnical Conf.*, Quebec City, May 1977.

405-10300-330-00

EFFECT OF SHIP PASSAGE ON UNDERHANGING ICE DAM FORMATION

(*c*) Mr. R. Carson, Dr. G. Tsang.
(*d*) Applied.
(*e*) To study the effect of ship passage on the formation of ice jam in a fragmented ice cover.
(*g*) Laboratory experiments showed that the passage of a ship through an unconsolidated ice cover can cause an underwater ice dam to form; the criteria for such an ice dam initiation is very much affected by the condition of the ice cover; for a given ice cover, a ship moving downstream is more likely to produce an ice jam than one moving upstream; and both high and low ship speeds are not favourable for ice dam formation. Somewhere in between there is a ship speed range at which ice dams are most likely to form.

405-10301-300-00

CRITERIA OF ICE COVER STABILITY

(*c*) Dr. G. Tsang, Mr. R. Carson, Dr. E. C. Chen.
(*d*) Theoretical, applied.
(*e*) To study the parameters which will cause the collapse of the upstream end of a loose ice cover and the formation of an ice jam.

405-10302-870-99

RECOVERY OF SPILLED OIL IN RIVERS FROM CUT SLOTS IN THE ICE COVER

(*b*) Prairie Region Oil Spill Containment and Recovery Advisory Committee.
(*c*) Dr. E. C. Chen, Dr. G. Tsang, Mr. R. Carson.
(*d*) Applied.
(*e*) To study the feasibility and the best way of recovering spilled oil from slots cut in the ice cover of rivers.

405-10303-870-00

OIL AND ICE STUDIES

(*c*) Dr. E. C. Chen, Dr. G. Tsang, Mr. R. Carson.
(*d*) Theoretical; applied.
(*e*) To study the rising of an oil jet; the managment of an oil slick; and the interaction of oil and ice under an ice cover and in ice-infested waters.

405-10304-300-90

ICE JAM FLOOD RISK MAPPING

(*b*) Atlantic Region, Inland Waters Directorate, Department of Fisheries and the Environment.
(*c*) Mr. R. Carson.
(*d*) Applied.
(*e*) To map the sites of probable flooding due to ice jamming in the Salmon River, Nova Scotia.

DALHOUSIE UNIVERSITY, Institute of Oceanography, Halifax, Nova Scotia, Canada B3H 3J5. Dr. Lloyd M. Dickie, Director.

406-09518-420-00

SURF ZONE AND NEARSHORE HYDRODYNAMICS

(*c*) A. J. Bowen and D. A. Huntley.
(*d*) Theoretical and field experimental; basic research.
(*e*) Develop theories of nearshore wave/motion and steady currents, and test theories by field experiments. Investigation of surf beat, edge waves and turbulent stresses on bottom sediment.
(*g*) See papers.
(*h*) **Hydraulic and Sedimentary Problems of Tidal Power Development of the Shubenacadie River Estuary-A Pilot Study**, A. J. Bowen, C. J. R. Garrett, Institute of Oceanography, *Dalhousie Univ. Rept.*, 47 pages, 1976.

Finite Amplitude Edge Waves, R. T. Guza, A. J. Bowen, *J. Marine Res.* **34,** pp. 268-293, 1976.

Resonant Interactions for Waves Breaking on a Beach, R. T. Guza, A. J. Bowen, *Proc. 15th Conf. on Coastal Engrg.*, Honolulu, Hawaii, July 1976 (in press).

Long Period Waves on a Natural Beach, D. A. Huntley, *J. Geophys. Res.* **81,** pp. 6441-6449, 1976.

Lateral and Bottom Forces on Longshore Currents, D. A. Huntley, *Proc. 15th Intl. Conf. on Coastal Engr.*, Honolulu, Hawaii, July 1976 (in press).

ENVIRONMENT CANADA, DEPARTMENT OF FISHERIES AND THE ENVIRONMENT, INSTITUTE OF OCEAN SCIENCES, PATRICIA BAY; OCEAN AND AQUATIC SCIENCES, PACIFIC REGION, 9860 West Saanich Road, Sidney, British Columbia, Canada V8L 3S2. R. W. Stewart, Director.

407-09519-410-00

MATHEMATICAL MODEL OF BURRARD INLET, B. C.

(*c*) Mr. A. B. Ages.
(*d*) Theoretical and field investigation; applied research.
(*e*) A two-dimensional numerical model, using finite difference methods for calculating tidal propagation in Burrard Inlet, including Vancouver Harbour, Indian Arm and Port Moody.

407-10237-400-00

MATHEMATICAL MODEL OF STRAIT OF GEORGIA AND JUAN DE FUCA STRAIT, B.C.

(*c*) Dr. P. B. Crean.
(*d*) Theoretical and field investigation; applied research.
(*e*) A two-dimensional numerical finite-difference model is under development for tidal propagation studies.

407-10238-420-00

STORM SURGE FORECASTING IN BEAUFORT SEA

(*c*) Dr. R. F. Henry.
(*d*) Theoretical and field investigation; applied research.
(*e*) A two-dimensional numerical model has been developed for operational forecasting of surge elevations, using predicted surface winds as input.

LASALLE HYDRAULIC LABORATORY LTD., 0250 St. Patrick Street, Lasalle, Quebec, Canada H8R 1R8. R. Hausser, President and General Manager.

408-09546-340-75

SENOKO POWER STATION THERMAL MODEL STUDY

(*b*) Montreal Engineering Company Limited.
(*d*) Experimental design.
(*e*) 1:600 horizontal and 1:150 vertical scale thermal model study of dispersion characteristics of discharge plume, the change in the average cooling water inlet temperature above ambient temperature and determination of the water surface contour of 2 °C temperature rise above ambient of the discharge heat plume.
(*f*) Completed.
(*g*) Initial design proved satisfactory. Combined density and tidal currents helped to replenish the intake area with a constant supply of water at nearly ambient temperature.
(*h*) Report submitted to MECO.

408-09547-340-96

SITE I POWER INTAKE STUDIES

(*b*) British Columbia Hydro and Power Authority.
(*d*) Experimental; design.
(*e*) Hydraulic studies on a 1:48 partial model of the following aspects: intake headloss for different transition shapes between the gate section and the penstock; gate downpull and risks of vibration; vortex formation at the intake.
(*f*) Completed.
(*g*) The study enabled to determine the best combination of intake gate section, transition length and shape. It was possible to combine headloss reduction and saving in construction costs. Persistence of vortex formation led to studies on a comprehensive model.
(*h*) Report submitted to B.C.H.P.A.

408-09548-870-90

OIL SPILLS

(*b*) Ministry of Transport–Canada.
(*d*) Experimental.
(*e*) Use of deflectors for diversion of a spill toward the North bank of the St. Lawrence River where the velocities are low enough for use of conventional means for recovery in case of oil spill along the Montreal refineries. Determination of the phenomenon and location of deflector stacks for best efficiency.
(*f*) Interim reports.
(*g*) Possibility of greatly improving the recovery percentage in case of spill.

408-09549-330-90

NAVIGATION–TRAVERSE SPIT

(*b*) Ministry of Transport, Canada.
(*d*) Experimental, operation.
(*e*) Study of the problems involving large vessels, such as supertankers, during passage, meeting or overtaking in restricted waters of the St. Lawrence navigation channel. Specific case of Traverse Spit (at the top of Ile d'Orléans) under study, model and ships scale 1/100, radio and T. V. monitored ships.
(*f*) Completed.

408-10239-340-70

GRAND GULF NUCLEAR STATION

(*b*) Ingersoll-Rand Company; Mississippi Power and Light Co.; Bechtel, Consultants.
(*d*) Model investigation; design.
(*e*) 1/10 scale model of circulating water pump well to develop internal configuration that will give acceptable flow entry to the pump bellmouths.
(*f*) Completed.

408-10240-340-70

INDIAN RIVER STATION, UNIT 4

(*b*) Ingersoll-Rand Company; Delmarva Power and Light Co.; Gilbert/Commonwealth Engineers and Consultants.
(*d*) Model investigation; design.
(*e*) 1/10 scale model of a section of the cooling tower basin and the intake sump. Verification of flow conditions under the bellmouth and in the sump in general.
(*f*) Completed.

408-10241-300-73

MANASAN CONTROL STRUCTURE

(*b*) Manitoba Hydro.
(*d*) Experimental design.
(*e*) 1/100 scale ice model studies. Under post diversion flow conditions of the Burntwood River at Thompson the risks of formation of a severe ice jam and consequent flooding due to rise in winter water levels imposed the need for construction of a control structure and ice boom preventing the formation of the aforementioned ice jam.
(*f*) Completed.
(*g*) The study enabled to determine the best design of the control structure and the minimum upstream level for satisfactory ice boom performance.
(*h*) Report submitted to Manitoba Hydro.

408-10242-400-73

GREAT WHALE ESTUARY

(*b*) Hydro-Quebec.
(*d*) Model investigation; applied research.
(*e*) Estuary model constructed to a horizontal scale of 1/400 and vertical scale of 1/75. Problems studied included shoaling of entrance (affected by wave action as well as tidal and river currents), bed movement in the model, salt water intrusion, and the effects thereon of proposed changes in the physical and hydraulic regimes of the estuary.
(*f*) Final report in progress.

408-10243-400-75

LA GRANDE ESTUARY

(*b*) Vézina, Fortier and Associates, Consulting Engineers; James Bay Energy Corporation.
(*d*) Model investigation; design.
(*e*) Estuary model (horizontal scale: 1/600, vertical scale: 1/150). Clear water tests to study the erosion problem and to optimize stabilization means. Ice tests (ice cover formation, break-up conditions). Emphasis has been placed on comparing conditions before and after the construction of La Grande Complex.
(*f*) Testing under way.

408-10244-210-70

RUPTURE DISC HEADLOSS TESTS

(*b*) Process Equipment Ltd., Montreal.
(*d*) Experimental, design.
(*e*) A complete 10 inch diameter flange and rupture disc assembly, which is designed to act as a safety relief valve in industrial plant piping systems, was set up in the laboratory. Precise flow and headloss measurements were made, from which the headloss coefficient for the ruptured disc was calculated. Parameters were developed so the coefficients could be applied to larger size installations as well.
(*f*) Completed.

408-10245-340-73

WASHINGTON PUBLIC POWER SUPPLY SYSTEM–UNITS 1 AND 4

(*b*) W.P.P.S.S., Richland, Wash., and United Engineers and Constructors Inc., Philadelphia, Consulting Engineers.
(*d*) Experimental, design.
(*e*) The circulating water pump well supplying the cooling towers was studied on a model at 1/13.5 scale. Detailed modifications were developed inside the sump to ensure uniform flow supply to the four horizontal axis pump intakes.
(*f*) Completed.

408-10246-340-73

CORNWALL PUMPED STORAGE SCHEME

(*b*) Consolidated Edison Company of New York.
(*d*) Experimental, applied research, design.
(*e*) A 1/84 scale model of the Hudson River was used to study the flows in the vicinity of the intake-outlet screen structure. Zones of the river supplying water during pumping and receiving the turbined effluent were defined over the complete tidal cycle. Theoretical analyses based on the model results allowed calculation of the amount of turbined water that was recirculated.
(*f*) Completed.

408-10247-340-73

NEAL STATION–UNIT 3

(*b*) Iowa Public Service Co., Sioux City; Ingersoll-Rand Pump Co., Phillipsburg, N.J.
(*d*) Experimental, design.
(*e*) The likelihood that the Missouri River will drop to levels below those foreseen when the pumphouse was built introduced the possibility of vortex formation that would disturb operation of the two vertical axis mixed flow pumps. A model at scale 1/11.55 was used to develop extreme remedial measures that should allow vortex-free operation of the pumps with very low river levels.
(*f*) Completed.

408-10248-340-73

LARAMIE RIVER STATION–UNITS 1 AND 2

(*b*) Missouri Basin Electric Power Cooperative; Burns and MacDonnell, Kansas City, Consulting Engineers; Hayward-Tyler Pump Co.
(*d*) Experimental, design.
(*e*) Two vertical axis propellor pumps, set in individual bays, supply water to the cooling system. Water returning from the plant arrived in canals on each side of the sump, at right angles to the bay centerlines. A 1/16 scale model was used to develop the sump modifications necessary to ensure uniform and vortex-free approach flows to the pumps.
(*f*) Completed.

408-10249-440-73

LAKE WINNIPEG REGULATION ICE STUDY

(*b*) Manitoba Hydro.
(*d*) Theoretical, design.
(*e*) Water flowing out the north end of Lake Winnipeg goes through a complex network of natural and man-made lakes and channels before arriving at Jenpeg Generating Station. When the station begins operating, it will alter the natural flows through the channels, in particular during winter. A computer study was carried out to define the ice cover conditions and levels all through the flow system, as a function of discharge and level in Lake Winnipeg.

408-10250-300-73

WINNIPEG RIVER ICE STUDY

(*b*) Manitoba Hydro, Winnipeg, Manitoba.
(*d*) Theoretical, design.
(*e*) It had been proposed that the six hydroelectric stations along the river be used to supply peak power for short periods each day, instead of the steady base load for which they were originally designed. The resulting wide discharge variations would modify the ice cover conditions in winter. A computer study was carried out to define the ice cover relations and resulting water levels, as well as recommending ice boom locations to establish and hold stable covers.
(*f*) Completed.

408-10251-350-73

EASTMAIN SPILLWAY–JAMES BAY PROJECT

(*b*) James Bay Energy Corporation; Lalonde, Girouard, Letendre, and Associates, Consulting Engineers, Montreal.
(*d*) Experimental; design.
(*e*) Study on a 1/100 scale model of a spillway located in a diversion canal and designed to carry a peak outflow of 211,000 cfs with a maximum head of 65 feet. Special attention was given to potential scouring of the riverbank and to flow conditions during winter.

408-10252-520-90

NAVIGATION–CRASH STOP ASTERN TESTS

(*b*) Transport Canada; Canadian Coast Guard.
(*d*) Experimental.
(*e*) 1/100 scale model study to evaluate the effect of certain parameters on the distance traveled by large vessels in coming to a stop. Use of radio-controlled self-powered tankers of 65,000, 110,000 and 227,000 DWT.
(*f*) Completed.

408-10253-630-68

SEWAGE TREATMENT PLANT–PUMPING STATION

(*b*) Montreal Urban Community; SNC Groupe, Montreal and Asselin, Benoit, Boucher, Ducharme, Lapointe, Inc., Consulting Engineers, Montreal.
(*d*) Experimental; design.
(*e*) Study of a 1/16 scale model of flow conditions in four wells housing 17 pumps (110,000 USGPM each) supplied by two interceptors serving the Montreal Urban Community. Also on a 1/24 comprehensive scale model of the treatment plant between the 17 discharging syphons and the settling tanks, study of flow and sediment distribution in canals leading to the screens and to the grit chambers.
(*f*) Completed.

408-10254-870-68

WATER TREATMENT PLANT–SEWAGE OUTFALL

(*b*) Montreal Urban Community.
(*d*) Experimental; design.
(*e*) Study on a 1/600 by 1/150 scale model reproducing the St. Lawrence River of the sewage outfall location for the 3,300 cfs water treatment plant.
(*f*) Completed.

408-10255-340-73

GENTILLY NUCLEAR POWER STATION UNIT NO 2–PUMPING STATION

(*b*) Hydro Quebec, Canatom Ltd.
(*d*) Experimental; design.
(*e*) 1/16 scale model study of flow conditions at pump entrance under various pumping conditions.
(*f*) Completed.

408-10256-870-68

FLOW INTERCEPTION FROM A COLLECTOR TO AN INTERCEPTOR

(*b*) Montreal Urban Community.
(*d*) Experimental; design.
(*e*) Model study to verify the design of a diversion chamber allowing interception of a nominal flow from a collector to an interceptor leading to a treatment plant (1/12 scale model).
(*f*) Completed.

408-10257-350-73

CANIAPISCAU DIVERSION TUNNEL AND SPILLWAY–JAMES BAY PROJECT

(*b*) James Bay Energy Corporation; Lemieux, Monti, Nadon, Roy, Inc., Consulting Engineers, Montreal.
(*d*) Experimental; design.
(*e*) A 1/100 scale model including a spillway and its tailrace canal (peak flow 130,000 cfs) and a diversion tunnel (peak flow 110,000 cfs). The main characteristic of the project is the superimposed arrangement of the spillway and canal on top of the diversion tunnel with the tailrace canal of the tunnel serving as a dissipating basin for the spillway flow. The model was used to investigate flow conditions mainly in the tailrace canal of the diversion tunnel and in the intake canal of the spillway. Calibration of both structures was made and flow conditions during winter with ice were examined.

408-10258-350-73

EASTMAIN, OPINACA, LA GRANDE (E.O.L.) CONTROL STRUCTURE–JAMES BAY PROJECT

(*b*) James Bay Energy Corporation; Lalonde, Girouard, Letendre and Associates, Consulting Engineers, Montreal.
(*d*) Experimental; design.
(*e*) A 1/100 scale model study of a three-gated control structure designed for a peak flow of 70,000 cfs. The study includes the investigation of various flow conditions and calibration of the structure. Excavation in the downstream reach as required by winter ice flow conditions is also being studied.

408-10259-300-90

UPPER RICHELIEU RIVER

(*b*) Environment Canada.
(*d*) Model investigation, design.
(*e*) Model constructed to a horizontal scale of 1/111 and a vertical scale of 1/45. The purpose of the study was to determine the effect of proposed water level controls, for flood control at high flows and to maintain environmentally acceptable levels at low flows.
(*f*) Completed.

408-10260-520-90

MOORING FORCES OF LARGE VESSELS BERTHED AT OFFSHORE TERMINALS

(*b*) Ministry of Transport, Canada.
(*d*) Model investigation; applied research.
(*e*) On a 1/100 scale model duplicating the Come-by-Chance terminal conditions, VLCC models, the largest being 412,000 DWT, were used to study the dynamics of mooring line forces generated as a result of combinations of wave conditions, lines-pretensioning, line-elongation characteristics, nylon-tail addition to steel lines, vessel loading, and mooring arrangements. With the view of developing practical guidelines for the general user, the program was expanded in a later phase to environmental conditions beyond those expected at the site of Come-by-Chance terminal.
(*f*) First and second interim reports in 1976; studies under way.

408-10261-430-96

GASPE COASTLINE ROD NO. 132

(*b*) Ministry of Transport, Quebec.
(*d*) Model investigation, design.
(*e*) Wave flume tests at scale 1/30 to determine design crest elevation of sea walls and protective slopes subject to breaking waves.
(*f*) Completed.

408-10262-430-96

RIMOUSKI SEA WALL

(*b*) Ministry of Transport, Quebec.
(*d*) Model investigation; design.
(*e*) Wave flume tests at scale 1/20 to investigate potential run-up and water projections on the road, as well as reflections from the wall towards the adjacent marina.
(*f*) Completed.

408-10263-350-73

LG3 WATER INTAKE

(*b*) James Bay Energy Corporation; S.N.C.-Cartier, Consulting Engineers.
(*d*) Model investigation; design.
(*e*) 1/100 scale model of forebay and intake structure. Tests included vortex observations and preparation of chronophotographic surface velocity charts. New approach walls and a higher elevation of the intake structure were adopted as a result of the investigation.
(*f*) Completed.

408-10264-350-73

MANIC 2 SPILLWAY STRUCTURE

(*b*) Hydro-Quebec.
(*d*) Model investigation; design.
(*e*) 1/80 scale model of existing structure, power station and tail-race to define remedial measures to hydraulic problems caused by the functioning of the spillway structure (high water levels and scour in the tailrace, water projections on the pulp wood chute and on the electric lines).

(*f*) Completed.

408-10265-340-73

LIMESTONE GENERATING STATION

(*b*) Manitoba Hydro through Crippen Acres Engineering.
(*d*) Experimental design.
(*e*) 1/500 horizontal and 1/150 vertical scale ice model studies. The Limestone Generating Station is to be built in a reach of the Nelson River subject to severe ice jamming. During the winter, under existing conditions the staging of the ice cover causes a rise in water level of about 15 meters above the open water conditions. The object of the model study is to determine winter water levels and stability of the ice cover under different diversion conditions.
(*f*) Study in progress.

408-10266-350-73

OUTARDES 2

(*b*) Hydro Quebec through Sometal Atlantic Limited and Asselin, Benoit, Boucher, Ducharme, Lapointe, Inc.
(*d*) Experimental design.
(*e*) 1/30 scale partial model study of regulating and bulkhead gates. Measurement of hydraulic downpull and determination of operating conditions giving gate vibration.
(*f*) Completed.
(*g*) The study enabled to determine gate knife edge shape giving minimum hydraulic downpull and operating conditions under which risks of gate vibration are to be expected.
(*h*) Report submitted to Hydro Quebec.

408-10267-860-65

WATER INTAKE FOR THE CITY OF MONTREAL WATER SUPPLY

(*b*) Public Works Department of the City of Montreal through Lalonde, Valois, Lamarre, Valois and Associates.
(*d*) Field investigation.
(*e*) Prototype frazil transport measurements and assessment of heating requirements to assure unhindered water supply during worst winter conditions.
(*f*) Completed.
(*g*) Investigation allowed to better understand the atmospheric and temperature conditions giving worst frazil ice transport and deposition at the Water Intake.
(*h*) Report submitted to the City of Montreal.

408-10268-350-73

LG3 SPILLWAY

(*b*) James Bay Energy Corporation through SNC Cartier.
(*d*) Experimental design.
(*e*) 1/100 scale model study of hydraulic design of the spillway and the energy dissipation downstream.
(*f*) Completed.
(*g*) The study enabled to determine the spillway flip-bucket design providing a desired jet dispersal and scour conditions for maximum probable discharge.
(*h*) Report submitted to the James Bay Energy Corporation.

408-10269-870-73

MANITOUNUK SOUND

(*b*) Hydro Quebec.
(*d*) Experimental design.
(*e*) 1/2,000 horizontal and 1/150 vertical scale hydraulic model study to determine the effects of power discharge on the salinity of the water as well as a comparison of its impact on the flow velocities and ice cover formation inside the sound under present conditions and after completion of the power project.
(*f*) Study in progress.

408-10270-350-87

SIDI SAAD DAM

(*b*) Ministry of Development, Tunisia, through SNC.
(*d*) Experimental design.
(*e*) 1/100 scale model study of hydraulic design of the spillway and energy dissipation downstream.
(*f*) Study in progress.

408-10271-350-73

FLOW DIVERSION FROM CANIAPISCAU RIVER TO LG4 RESERVOIR

(*b*) James Bay Energy Corporation; Lemieux, Monti, Nadon, Roy and Associates, Consulting Engineers, Montreal.
(*d*) Theoretical, design.
(*e*) Study of the most appropriate route and required embankments and excavations to discharge 40,000 cfs over 136 miles of land, lakes or small rivers even during the worst winter ice conditions.

408-10272-210-73

TEMENGOR HOLLOW CONE VALVES

(*b*) Hydroelectric Authority of Malaysia, Shawinigan Engineering Co. Ltd., Montreal, Consulting Engineers.
(*d*) Experimental, design.
(*e*) Operation of the two valves as short term bottom outlets installed in a diversion tunnel had resulted in significant splashing of an actively used work platform. Model studies at scale 1/30 were carried out to identify the source of the splashing and to develop remedial works required.
(*f*) Completed.

408-10273-340-73

POINT LEPREAU PUMPHOUSE

(*b*) New Brunswick Electric Power Commission.
(*d*) Experimental, design.
(*e*) The pumphouse contains four small vertical axis propeller pumps and two large concrete volute pumps that circulate raw sea water through the cooling system of the thermal power plant.
(*f*) Completed.
(*g*) Detailed modifications were developed in the three separate sumps so that water supply to all of the pumps was uniform and free of vortexing tendencies. Particular care was necessary to guarantee consistent operation over the complete tidal cycle involving water level changes up to 50 ft in the supply canal from the Bay of Fundy.

408-10274-340-73

INDIAN POINT GENERATING PLANTS

(*b*) Consolidated Edison Company of New York.
(*d*) Experimental, applied research, design.
(*e*) A 1/84 scale model of the Hudson River was used to study the flows in the vicinity of the cooling water intakes and common outlet. Zones of the river supplying the intakes were defined as well as the trajectories of the heated effluent over the complete tidal cycle. Theoretical analyses based on the model results allowed calculation of the amount of effluent water that was recirculated.
(*f*) Completed.

McGILL UNIVERSITY, Department of Chemical Engineering, 3480 University St., Montreal, Quebec, Canada H3A 2A7. Drs. A. S. Mujumdar and W. J. M. Douglas.

409-10781-050-90

IMPINGING JET FLOW, HEAT AND MASS TRANSFER

(*b*) N. R. C., Ottawa; Pulp & Paper Research Institute of Canada.
(*c*) Dr. W. J. M. Douglas and Dr. A. S. Mujumdar.
(*d*) Computational; experimental; several Ph.D. and M.Eng. theses.
(*e*) Numerical models have been developed to predict the flow, heat and mass transfer characteristics of two-dimensional/axisymmetric, laminar/turbulent jets of air impinging normally on a permeable wall. Computer programs have

been developed to simulate round swirling impinging jet including effect of suction or blowing at the impingement surface. Another code predicts the transfer rates under conditions of coupled heat and mass transfer. A unique experimental facility has been designed and made operational to measure the instantaneous heat flux on the surface of a porous metal drum rotating at high rpm's and exposed to heating and cooling slot jets. Parameters studied or under study include: effect of nozzle design, Reynolds number, nozzle-suction rate at the wall, effect of inter-jet interaction for multiple slot jets, etc. Specific application motivating this work is the high-speed drying of newsprint using the Papridryer concept.

(*g*) Various new experimental rigs for testing the simulation programs are being designed and constructed.

(*h*) List of publications available upon request.

409-10782-140-00

COUPLED HEAT AND MASS TRANSFER IN ENTRY FLOWS

(*c*) Dr. A. S. Mujumdar.

(*d*) Computational, basic.

(*e*) A computer code has been developed to predict the effect of high mass transfer rates on the flow, heat and mass transfer in the entrance length of a laminar tube flow. The code solves the full conservation of species (chosen to be air-water vapor), Navier-Stokes equations and the energy equation subject to appropriate boundary conditions for a Newtonian fluid.

(*g*) The code is being extended to include effects of swirl of arbitrary profile introduced at the inlet.

409-10783-020-00

TURBULENT FLOWS IN ASYMMETRIC CHANNELS

(*c*) Dr. A. S. Mujumdar.

(*d*) Experimental, applied.

(*e*) Hot-wire and laser Doppler velocimeter surveys of the mean velocity and turbulence characteristics of turbulent flow in specially designed asymmetric channels will be made. Results are of interest in design of headboxes of modern high-speed papermachine which are fully hydraulic.

(*g*) Selection of various possible channel configurations is under way in consultation with papermachine manufacturers.

MEMORIAL UNIVERSITY OF NEWFOUNDLAND, Faculty of Engineering and Applied Science, St. John's, Newfoundland, Canada A1C 5S7.

410-10305-050-90

BUOYANT WALL JETS APPLIED TO OCEAN OUTFALLS

(*b*) National Research Council of Canada.

(*c*) J. J. Sharp, Associate Professor and B. D. Vyas, Post-Doctoral Fellow.

(*d*) Experimental and theoretical research.

(*e*) Study of various mathematical models of ocean outfalls and development of a mathematical model for dilution achieved by an axisymmetric buoyant wall jet, and comparison with experimental results.

(*f*) Studies on two-dimensional buoyant wall jets continued.

(*g*) The research results could be utilized for an efficient design of ocean outfalls. The buoyant wall jets are found to have higher dilution capacity than the free jets discharged at the same Froude number and depth to diameter ratio.

(*h*) **The Use of a Buoyant Wall Jet to Improve the Dilution of a Submerged Outfall,** J. J. Sharp, *Proc. Instn. Civil Engrs.* **59,** 2, pp. 527-536, Sept. 1975.

Application of Dimensional Reasonings to Thermal Systems, J. J. Sharp, *J. Franklin Institute* **299,** 3, pp. 191-197, Mar. 1975.

The Buoyant Wall Jet, J. J. Sharp, B. D. Vyas, *Proc. Instn. of Civil Engrs.* (in press).

Mathematical and Physical Models of the Ocean Outfall Performance, J. J. Sharp, B. D. Vyas, *7th Intersociety Conf. on Environmental Systems,* San Francisco, July 11-14, 1977 (communicated).

410-10306-360-00

STUDIES ON HYDRAULIC JUMP

(*c*) J. J. Sharp, Associate Professor.

(*d*) Experimental.

(*e*) The formation of hydraulic jump at an abrupt step is compared to that at a step with rounded edge.

(*h*) **Observations on Hydraulic Jump at Rounded Step,** J. J. Sharp, *ASCE* **100,** pp. 787-795, June 1974.

410-10307-210-90

RESPONSE OF A SUBMERGED COMPOSITE PIPE

(*b*) National Research Council of Canada.

(*c*) Dr. D. B. Muggeridge.

(*d*) Experimental and theoretical–M. Eng.

(*e*) Vibration characteristics of anisotropic cylindrical shells in a fluid medium have been investigated theoretically and confirmed experimentally. Numerical results are given for the following cases: A shell in air; a shell containing a fluid; a shell immersed in a fluid, and a shell containing a fluid that is immersed in a fluid.

(*g*) The presence of a fluid decreases the natural frequency of vibration by almost an order of magnitude.

Results for a shell immersed in a fluid and a shell containing a fluid are almost identical.

Even lower frequencies occur when a shell containing a fluid is submerged.

The natural frequency of a shell, that is partially submerged, decreases rapidly until the shell is approximately one quarter submerged. Thereafter the natural frequency is relatively insensitive to further submergence.

(*h*) **Vibration Characteristics of Reinforced Plastic Pipes in a Fluid Medium,** W. N. Dong, D. B. Muggeridge, *IEEE Ocean Intl. Conf.,* Halifax, N.S., pp. 418-424, Aug. 1974.

Dynamics of a Fluid Carrying Fiber-Reinforced Pipe, W. N. Dong, D. B. Muggeridge, *Proc. 5th Canadian Congr. of Applied Mechanics,* Fredericton, May 1975.

Both reports available from the Ocean Engrg. Information Centre, Faculty of Engrg. and Applied Science, Memorial Univ. of Newfoundland, St. John's, Newfoundland, Canada A1C 5S7.

410-10308-430-90

WAVE FORCES ON MARINE STRUCTURES

(*b*) National Research Council of Canada.

(*c*) Dr. D. B. Muggeridge.

(*d*) Experimental and theoretical, M. Eng. thesis.

(*e*) A wave channel (60m × 4.5m × 3m) is being commissioned to study the effects of wave forces on marine structures. A closed-loop hydraulic system is used to actuate a sealed piston-type wave paddle and a variable slope beach is employed to absorb the wave energy. Regular and random waves are capable of being generated and wave and force spectra are analyzed by an HP 5451B Fourier Analyzer system.

410-10309-840-90

SEASONAL FLOW IN CHANNELS DRAINING PEATLANDS

(*b*) National Research Council of Canada.

(*c*) J. Waterhouse, Assoc. Professor.

(*d*) Field investigation, experimental.

(*e*) Seasonal changes in groundwater level, in soil moisture, in peat characteristics and in the drainage channel conditions contribute to flow variations. The interrelationships will be studied in laboratory and field, special attention being paid to freezing conditions.

410-10310-140-90

HEAT, MASS, AND MOMENTUM TRANSFER IN THE MELTING OF ICE IN SALINE WATER

(*b*) National Research Council of Canada.
(*c*) N. W. Wilson, Assoc. Professor.
(*d*) Theoretical and experimental; basic and applied.
(*e*) The boundary layer regions near an ice wall melting into saline water are being investigated to provide information concerning combined free and forced convection. Geometries considered include a horizontal ice sheet with flow above or below the sheet, and a vertical ice sheet. Will provide information pertaining to characteristics of iceberg and sheet ice melting in saline water.
(*g*) Enhancement of melting rates occur in the horizontal case because of buoyancy forces. Additionally, at combined convection conditions, small recirculating zones occur within the boundary layers.

410-10311-450-90

FINITE ELEMENT FORMULATION OF VISCOUS SEA ICE MODELS

(*b*) National Research Council of Canada.
(*c*) D. S. Sodhi, Assoc. Professor.
(*d*) Theoretical, applied research.
(*e*) The drift of pack ice in the Strait of Belle Isle under different environmental conditions is studied, using the finite element method.
(*h*) **A Finite Element Formulation of a Viscous Sea Ice Drift Model,** D. S. Sodhi, W. D. Hibler. Abstract sent for acceptance at the *ICSI/AIDJAX Symp. on Sea Ice–Processes and Models*, Sept. 4-9, 1977, Seattle, U.S.A.

410-10312-450-90

EFFECT OF OCEAN CURRENT FIELD ON ICEBERG DRIFT

(*b*) National Research Council of Canada.
(*c*) W. E. Russell, Assoc. Professor.
(*d*) Theoretical experimental and field investigation; applied research.
(*e*) The effect of direction and velocity changes of ocean currents on the response of iceberg drift is studied. Numerical model is developed and verified by laboratory experiments and field observations.
(*g*) Laboratory and field work in progress.
(*h*) **Analysis of Iceberg Trajectories,** N. Riggs, W. E. Russell, *2nd CSCE Atlantic Regional Hydrotechnical Conf.*, Amherst, N.S., 1976.
Field Study of Local Iceberg Motion, W. E. Russell, N. Riggs, Q. Robe, *POAC Conference*, Memorial University, Sept. 1977.
Boundary Layer Flow Around a Drifting Iceberg, W. E. Russell, N. Riggs, *POAC Conference*, Memorial University, Sept. 1977.

410-10313-210-88

PULSED FLOW IN CIRCULAR PIPES

(*b*) Institute of the Statistical Mechanics of Turbulence, Marseille, France.
(*c*) W. E. Russell, Associate Professor.
(*d*) Theoretical: basic research.
(*e*) The behaviour of pulsed flow at low and high frequencies is studied.
(*h*) **Tourbillents annulairres on ecoulement pulsé,** C. Béguier, W. E. Russell, *Deuxieme Congrés des Mechanique*, Toulouse, France, Sept. 1975.
Systéme Stationairre en Ecoulement Pulsé Axisymmetrique, C. Béguier, W. E. Russel, *Euromech* 73, Aix-en-Provence, France, 1976.

NATIONAL RESEARCH COUNCIL, Division of Mechanical Engineering, Hydraulics Section, Montreal Road, Ottawa, K1A 0R6, Canada. J. Ploeg, Section Head.

411-06602-400-90

TIDAL HYDRAULIC MODEL OF THE ST. LAWRENCE RIVER AND ESTUARY

(*b*) Ministry of Transport.
(*c*) Mr. J. Ploeg, Dr. B. D. Pratte.
(*d*) Experimental, applied research.
(*e*) A hydraulic model of the tidal reach of the river has been constructed and calibrated for the study of navigation improvements.
(*h*) **Computer Control and Data Acquisition of a Tidal Model,** E. R. Funke, *MH-110*, Dec. 1972.

411-06603-400-90

MATHEMATICAL MODEL OF THE ST. LAWRENCE RIVER AND ESTUARY

(*b*) Ministry of Transport.
(*c*) N. Crookshank.
(*d*) Theoretical; applied research.
(*e*) A combined one- and two-dimensional numerical model, using finite difference methods of calculating tidal propagation along the St. Lawrence River.
(*h*) **Numerical Model Studies of the St. Lawrence River,** D. Prandle, N. Crookshank, July 1972.

411-08133-420-90

FORCES ON OFF-SHORE STRUCTURES

(*b*) Public Works–Canada.
(*c*) Dr. G. Mogridge, W. Jamieson.
(*d*) Experimental, theoretical; applied research.
(*e*) Using a scale model of a deep water off-shore mooring point, wave forces sensed by strain gauges are recorded on-line with an EAI-640 computer. Regular and random waves are used.
(*h*) **A Design Method for the Estimation of Wave Loads on Square Caissons,** G. R. Mogridge, W. W. Jamieson, *LTR-HY-57*, Oct. 1976.
Wave Loads on Large Circular Cylinders: A Design Method, G. R. Mogridge, W. W. Jamieson, *MH-11*, Dec. 1976.

411-09562-330-90

MIRAMICHI CHANNEL STUDY

(*b*) Ministry of Transport.
(*c*) D. H. Willis.
(*d*) Experimental, applied research.
(*e*) A scale model study of the Miramichi Estuary, N. B., to determine the effects of deepening the navigation channel on the flow regime and to define locations of dumping grounds.
(*f*) Complete.
(*h*) **Miramichi Channel Hydraulic Investigation,** D. H. Willis, *LTR-HY-56*, Apr. 1977.

411-10314-430-90

BREAKWATER STABILITY STUDY

(*b*) Public Works–Canada.
(*c*) G. W. T. Ashe, J. Ploeg.
(*d*) Experimental, applied research.
(*e*) A study to determine parameters effecting stability of rubble mound breakwaters, including various new types of armour.
(*g*) It appears that wave grouping effects in irregular waves affect stability criteria.
(*h*) **The Problem of Defining Design Wave Conditions,** J. Ploeg, R. R. Johnson, *Ports 1977 Conf.*, Mar. 1977.

411-10315-720-00

SIMULATION OF IRREGULAR WAVES IN LABORATORY FLUMES

(*c*) E. Mansard, E. Funke.
(*d*) Experimental, theoretical, basic research.
(*e*) A study to develop new techniques to simulate ocean wave conditions, including wave grouping effects.

411-10316-420-00

MOORING FORCES ON FLOATING STRUCTURES

(*c*) R. R. Johnson, N. Crookshank, B. D. Pratte.
(*d*) Experimental, theoretical, applied research.
(*e*) A study to determine forces on and motions of offshore structures, including vessels moored in shallow water exposed to waves.

411-10317-420-00

PROPAGATION OF WAVES IN SHALLOW WATER

(*c*) R. R. Johnson, N. Crookshank.
(*d*) Theoretical, applied research.
(*e*) The development of numerical modeling techniques to propagate random wave conditions from deep into shallow water, to define input conditions for other laboratory wave studies.

UNIVERSITY OF NEW BRUNSWICK, Department of Civil Engineering, Fredericton, New Brunswick, E3B 5A3, Canada. Dr. K. S. Davar, Professor of Hydrosciences.

412-09571-020-00

DISPERSION IN A RECTANGULAR CONDUIT WITH RELATIVELY LARGE ROUGHNESS ON ONE BOUNDARY

(*b*) National Research Council of Canada.
(*d*) Theoretical and experimental (laboratory covered flume); basic research; Doctoral dissertation.
(*e*) Evaluation of the longitudinal dispersion coefficient for varying roughness sizes and spacings.
(*h*) **Effects of Large Roughness on Resistance and Dispersion in Conduits,** E. Ismail, N. Abd El-Hadi, K. S. Davar, *Proc. 3rd Natl. Hydrotechnical Conf.*, Canadian Soc. Civil Engrg., Quebec City, pp. 453-474, May 1977.

412-09572-210-90

RESISTANCE TO FLOW IN A RECTANGULAR CONDUIT WITH RELATIVELY LARGE ROUGHNESS ON ONE BOUNDARY

(*b*) National Research Council of Canada.
(*d*) Theoretical and experimental (laboratory study in rectangular duct); basic research with potential applications to ice covered rivers; Doctoral dissertation.
(*e*) Composite resistance (conduit) and component resistances (very rough and smooth boundaries) evaluated in a rectangular conduit with very large roughness strips of various sizes at different spacings.
(*f*) Nearing completion.
(*h*) **Effects of Large Roughness on Resistance and Dispersion in Conduits,** E. Ismail, N. Abd El-Hadi, K. S. Davar, *Proc. 3rd Natl. Hydrotechnical Conf.*, Canadian Soc. Civil Engrg., Quebec City, pp. 453-474, May 1977.

ONTARIO HYDRO, 700 University Avenue, Toronto, Ontario, Canada M5G 1X6. Mr. J. B. Bryce, Manager, Hydraulic Studies.

413-09573-340-00

BRUCE GENERATING STATION "B," COOLING WATER OUTFALL DUCT

(*d*) Experimental; design.
(*e*) A 1:25 scale model of the closed duct used to convey cooling water from the condenser to the open surface outfall channel. Model used to determine design details and performance, i.e., head loss, for maximum economic efficiency.
(*f*) Test programme completed; model dismantled.

413-09574-340-00

BRUCE GENERATING STATION "B," COOLING WATER OUTFALL CHANNEL

(*d*) Experimental, design.
(*e*) A 1:60 scale model of the open-surface channel used to return spent cooling water from the plant to Lake Huron. Model used to determine design details and performance, to reduce head loss and to promote effective mixing of the cooling water with the ambient body of water of Lake Huron for quick heat dispersion.
(*f*) Test programme completed; model dismantled.

413-09575-340-00

PICKERING GENERATING STATIONS "A" AND "B"

(*d*) Experimental; design.
(*e*) A 1:120 scale model of the condenser cooling water intake and outfall, including the adjacent area of Lake Ontario, affected by the once-through cooling process. Model used to study hydraulic design details of intake and outfall works, to prevent sediment intake, cooling water recirculation and to improve efficiency of heat dispersion of cooling water waste heat.
(*f*) Investigation completed; model dismantled.

413-09576-340-00

PICKERING GENERATING STATIONS "A" AND "B"–SPENT FUEL BAY

(*d*) Experimental, operation.
(*e*) An investigation to determine impact velocities in case of accidental and uncontrolled release into the spent fuel bay of a flask containing spent fuel bundles. Model fuel flasks constructed to five scales, ranging from 1:100 to 1:12, to determine an allowance for "scale effects." High speed movie techniques used in analysis.
(*f*) Investigation completed; model dismantled.

413-09577-340-00

PICKERING GENERATING STATION "B"–C. W. PUMPWELL

(*d*) Experimental; design.
(*e*) A 1:20 scale model of one condenser cooling water pumpwell. Model used to develop hydraulic design details for acceptable suction conditions.
(*f*) Investigation completed; model dismantled.

413-09578-340-00

BRUCE HEAVY WATER PLANT–WATER HANDLING SYSTEM

(*b*) Lummus Company of Canada Limited.
(*c*) Mr. D. Ross, 255 Consumers' Road Unit 2, Willowdale, Ontario, Canada, M2J 4H4.
(*d*) Experimental; design.
(*e*) A 1:50 scale model of the system comprising intake tunnel, forebays, pumps and intake and outfall channels to convey process and cooling water to and from the heavy water extraction facilities. Model used to determine design details and compliance with the exacting performance specifications, as required by the extraction process.
(*f*) Investigation completed; model dismantled.

413-09579-340-00

WESLEYVILLE GENERATING STATION–CONDENSER COOLING WATER SYSTEM

(*d*) Experimental; design.

254-330 O - 78 - 19

(*e*) A 1:25 scale model comprising the vertical inlet shaft, forebay, pumpwell inlets, condenser outlets, return duct, outfall channel, as well as an internal recirculation duct to release warm water into the forebay under icing conditions and a tempering pumphouse to pump cold water into outfall channel for reduction of temperature of cooling water at the point of return to Lake Ontario. Model used to determine details of hydraulic design and to check cooling water system performance for this 2000 MW oil-fired thermal station.
(*f*) Investigation continuing in the area of tempering and cooling water flow mixing.

413-09580-340-00

SO_2 SCRUBBER–PILOT PLANT

(*d*) Experimental; design.
(*e*) A 1:20 scale model of the gas intake, spray tower, demister and re-heat sections. Model used to develop the duct layout to obtain even flow distribution in the critical cross-sections.
(*f*) Investigation completed; model dismantled.

413-09581-340-00

ONCE-THROUGH CONDENSER COOLING WATER SYSTEMS–INTAKE DEVELOPMENT

(*d*) Experimental; development.
(*e*) A facility to carry out development work of off-shore submerged condenser cooling water intakes for large fossil-fired and nuclear thermal generating stations. Studies aim at developing a number of intake designs with suitable characteristics regarding plant operation and protection of the environment.
(*f*) Facility operational.

413-10318-420-00

SUBMERGED CONDENSER COOLING WATER INTAKE STRUCTURES-WAVE FORCES

(*d*) Experimental; design.
(*e*) A model test programme to ascertain dynamic wave loads on large submerged cooling water intake structures for several thermal generating stations. Tests conducted at a scale of 1:50.
(*f*) Investigation completed; model dismantled.

413-10319-850-00

PICKERING G. S. "A"–ELECTRIC FISH BARRIER

(*d*) Experimental; design.
(*e*) A 1:8 scale model of the barrier electrodes positioned at the inlet to the cooling water channel. Model used to develop an electrode design that would be stable under the action of wave forces prevailing in the area.
(*f*) Investigation completed; model dismantled.

413-10320-340-00

PICKERING GENERATING STATION "B" COOLING WATER OUTFALL TEMPERING

(*d*) Experimental; design.
(*e*) A 1:60 scale model of the condenser cooling water return structure. Model used for the hydraulic design of a side outlet to introduce water at ambient temperature into the condenser coolant stream for reduction of temperatures to conform with environmental guide lines. Design objective: efficient mixing of warm and cold water streams to achieve uniform temperatures at the monitoring point.
(*f*) Investigation completed, model inactive.

413-10321-340-00

WESLEYVILLE G.S.–C.W. PUMPWELL

(*d*) Experimental; design.
(*e*) A 1:6 scale model of one condenser cooling water pumpwell. Model used to develop hydraulic design details for acceptable suction conditions.
(*f*) Investigation completed; model dismantled.

413-10322-340-00

WESLEYVILLE GENERATING STATION–GAS FLOW STUDY OF PRECIPITATOR DUCTING

(*d*) Experimental; design.
(*e*) A 1:16 scale model comprising the electrostatic precipitator and gas ducting leading into and out of it. Model used for design of flow guiding devices to ensure a flow distribution in critical cross-sections as required for effective operation of precipitator.
(*f*) Investigation completed; model dismantled.

413-10323-340-00

BRUCE G.S. "A"–COOLING WATER INTAKE

(*d*) Experimental; design.
(*e*) A 1:25 scale model of the station's condenser cooling water intake. Studies aiming at producing hydraulic layout that will satisfy economic, operational and environmental criteria of plant design.

413-10324-340-00

BRUCE NUCLEAR COMPLEX

(*d*) Experimental; design; operation.
(*e*) A scale model–horizontal scale 1:240, vertical scale 1:120–featuring the cooling water outlets of three nuclear generating stations and one large heavy water production facility. Objective of study is to ascertain the deployment and interaction of the four thermal plumes to ensure satisfactory operating conditions and compliance with environmental guide lines.
(*f*) Model construction completed; installation of controls, instrumentation and data acquisition and processing equipment in progress.

413-10325-340-00

DARLINGTON GENERATING STATIONS "A" AND "B"

(*d*) Experimental; design.
(*e*) A scale model–horizontal scale 1:250, vertical scale 1:125–of the condenser cooling water intake and outfall, including the adjacent area of Lake Ontario, affected by the once-through cooling process. Model used to study hydraulic design details of intake and outfall works to prevent cooling water recirculation and to improve efficiency of heat dispersion of cooling water waste heat.
(*f*) Investigation in progress.

413-10326-340-00

DARLINGTON GENERATING STATION "A"–WASTE HEAT MANAGEMENT

(*d*) Experimental; development.
(*e*) A 1:120 scale model comprising the plant's cooling water intake and outfall works and the shore region of Lake Ontario contiguous to the cooling water return structure. Model used to determine feasibility of using spent cooling water to create a warm water beach for public use.
(*f*) Investigation completed; model removed.

413-10327-340-00

THUNDER BAY GENERATING STATION EXTENSION–GAS FLOW STUDY OF PRECIPITATOR DUCTING

(*d*) Experimental; design.
(*e*) A 1:16 scale model comprising the electrostatic precipitator and gas ducting leading into and out of it. Model used for design of flow guiding devices to ensure a flow distribution in critical cross-sections as required for effective operation of precipitator.
(*f*) Investigation completed; model dismantled.

413-10328-220-00

MARMION LAKE–SEDIMENT ENTRAINMENT STUDY

(*d*) Experimental; field investigation; design.

(*e*) Field sampling and laboratory test programme to establish sediment entrainment characteristics. Results to be used to determine the response of Lake bed sediments, consisting of very fine grained mine tailings to flow in the Lake to be induced by the circulation of condenser cooling water by a proposed thermal generating station.
(*f*) Investiation completed.

413-10329-340-00

BRUCE GENERATING STATION "B" TUNNEL PORTAL

(*d*) Experimental; design.
(*e*) A 1:25 scale model of the transition from the condenser cooling water tunnel into the pumphouse forebay. Model used to minimize head losses in the transition to arrive at optimum hydraulic design.
(*f*) Investigation completed; model dismantled.

413-10330-340-00

BRUCE GENERATING STATION "A" SPRAY-DOUSING SYSTEM-RISER PIPES

(*d*) Experimental; design.
(*e*) A 1:14 scale model of four riser pipes to convey water from a storage tank to dousing spray headers. Model used to check a riser pipe redesign with respect to hydraulic layout and structural soundness.
(*f*) Investigation completed; model inactive.

413-10331-350-00

WHITEDOG GENERATING STATION-SPILLWAY CALIBRATION

(*d*) Experimental; operation.
(*e*) A 1:50 scale model of the powerhouse and spillway section of an existing hydroelectric plant. Model used to ascertain spillway discharge coefficients to improve accuracy of flow records for the station.
(*f*) Investigation completed; model inactive.

QUEEN'S UNIVERSITY, Department of Civil Engineering, Kingston, Canada K7L 3N6.

414-10513-220-90

THE EFFECT OF PRESSURE GRADIENTS ON OSCILLATORY CURRENT MOTION ON SAND BEDS

(*b*) National Research Council.
(*c*) Dr. A. Brebner.
(*d*) Basic research.
(*e*) Oscillatory motion representing prototype wave currents at the sea bed are reproduced along with vertical water pressure gradients, both into and out of the sand bed to find the effect of the latter on the sand particle motion.
(*h*) **Sea Bed Mobility Under Vertical Pressure Gradients,** T. Carstens, A. Brebner, J. W. Kamphuis, *B.O.S.S. Intl. Conf. Proc.*, Trondheim, Aug. 1976.

414-10514-430-90

THE EFFECT OF BREAKAGE ON THE STABILITY OF DOLOS ARMOUR UNITS

(*b*) National Research Council.
(*c*) Dr. A. Brebner.
(*d*) Basic research.
(*e*) Oscillatory motion is effected on dolos units, both broken and unbroken, and carried with quarry stone at the same weight to find the effective value of K_D.

414-10515-370-90

BLOCKAGE, PLUG FLOW AND SLIDING BEDS IN PIPELINES TRANSPORTING SOLIDS

(*b*) National Research Council of Canada.
(*c*) Dr. K. C. Wilson.
(*d*) Experimental and theoretical project.
(*e*) This topic is directly associated with design problems which occur in pipelines used industrially for transporting solids. A mathematical model of the phenomena being investigated has been proposed. Experimental investigations will be combined with further analytical work on the model.
(*h*) **Slip Model Correlation of Dense Two-Phase Flow,** K. C. Wilson, *Proc. 2nd Intl. Conf. Hydraulic Transport of Solids in Pipes*, BHRA Fluid Engrg., 1972.
Co-Ordinates for the Limit of Deposition in Pipeline Flow, K. C. Wilson, *Proc. 3rd Intl. Conf. Hydraulic Transport of Solids in Pipes*, BHRA Fluid Engrg., 1974.
Stationary Deposits and Sliding Beds in Pipes Transporting Solids, K. C. Wilson, *Proc. 1st Intl. Symp. Dredging Technology*, BHRA Fluid Engrg., 1975.

414-10516-130-90

ENTRAINMENT OF SOLID PARTICLES BY TURBULENT SUSPENSION

(*b*) National Research Council of Canada.
(*c*) Dr. K. C. Wilson, Dr. W. E. Watt.
(*d*) Theoretical project.
(*e*) The efficiency of solids pipelining is directly linked to effective turbulent suspension. However the effect of the particle size relative to scale of turbulence has generally been ignored. The present work accounts for this effect and gives a formulation which is in accord with the experimental evidence.
(*h*) **Influence of Particle Diameter on the Turbulent Support of Solids in Pipeline Flow,** K. C. Wilson, W. E. Watt, *Proc. 3rd Intl. Conf. Hydraulic Transport of Solids in Pipes*, BHRA Fluid Engrg., 1974.

414-10517-370-90

UNIFIED ANALYTIC MODEL FOR SOLID-LIQUID PIPELINE FLOW

(*b*) National Research Council of Canada.
(*d*) Theoretical and experimental, basic research.
(*e*) Results from the previous projects on deposition and turbulent entrainment are combined into a unified analytical model. Comparison with pilot plant and prototype data shows high success in the predictions of the analytic model.
(*h*) **A Unified Physically-Based Analysis of Solid-Liquid Pipeline Flow,** K. C. Wilson, *Proc. 4th Intl. Conf. Hydraulic Transport of Solids in Pipes*, BHRA Fluid Engrg., 1976.
New Techniques for the Scale-Up of Pilot-Plant Results to Coal Slurry Pipelines, K. C. Wilson, D. G. Judge, *Proc. Intl. Symp. Freight Pipeline*, Washington, D.C., 1976.

414-10518-810-00

ECONOMIC APPROACH TO OPTIMIZING DESIGN PARAMETERS

(*c*) Dr. K. C. Wilson, Dr. W. E. Watt.
(*d*) Theoretical (M.Sc. thesis), basic research.
(*e*) In the absence of uncertainty, the best design could be determined by economic optimization. It is found that the uncertainty inherent in the real-world use generally requires a shift in the design optimum. The magnitude of the shift and the cost associated with uncertainty are expressed as functions of the uncertainty in the input data.
(*h*) **Economic Approach to Optimizing Design Parameters,** W. E. Watt, K. C. Wilson, *Proc. 14th Coastal Engrg. Conf.* 3, ASCE, 1974.
Uncertainty in Mathematical Modeling of Northern Rivers, K. C. Wilson, W. E. Watt, S. P. Trevellick, *3rd Natl. Hydrotech. Conf.*, CSCE, 1977.

414-10519-000-90

MEASUREMENT OF THE FLUCTUATING VELOCITIES OF TURBULENCE IN A CIRCULAR COUETTE FLOW

(*b*) National Research Council of Canada.
(*c*) Dr. M. S. Yalin.

(*d*) Theoretical and experimental. Basic research, carried out by Dr. T. Tarimcioglu (Post Doctoral Fellow).
(*e*) The Couette flow is generated by two coaxial cylinders; speed variable, flow boundaries smooth. The root mean square values of all three fluctuating velocity components u'_r, u'_w, u'_z are measured as functions of the position (r,z). The measurements are carried out with the aid of a laser Doppler anemometer. Fluid is water, various values of the Reynolds number are achieved by varying the angular velocity ω and thus the relative linear velocity ωR_1. The distribution of the cross-correlation coefficients ψ_{ij} is also being determined.

414-10520-200-90

THE INFLUENCE OF CONCENTRATION OF SUSPENDED SEDIMENT ON THE FLUCTUATING AND THE AVERAGE VELOCITIES OF TURBULENCE IN AN OPEN CHANNEL

(*b*) National Research Council of Canada.
(*c*) Dr. M. S. Yalin.
(*d*) Theoretical and experimental (M.Sc. thesis), basic research.
(*e*) The contemporary approach rests on the assumption that the presence of suspended load alters the value of the Von Karman constant, without affecting the logarithmic form of the distribution of time average velocities. It appears that this may be so in the special case of a uniformly distributed sediment concentration. It is intended to reveal how the logarithmic form is affected depending on the nonuniformity degree (dC/dy) of the concentration distribution $C = f(y)$. The analogous case will be investigated for the root mean square values of the fluctuating velocities u_i'.

414-10521-220-90

ON THE TIME GROWTH OF DUNES FORMED BY A TURBULENT OPEN CHANNEL FLOW

(*b*) National Research Council of Canada.
(*c*) Dr. M. S. Yalin.
(*d*) Mainly experimental (M.Sc. thesis); basic research.
(*e*) It takes a certain duration (T) for dunes to grow to their fully developed size, starting from the flat initial sand bed (newly dredged bed of a river). The aim of the present measurements is to reveal how the "duration of development" T varies as a function of the parameters determining the flow and the bed material. An auxilliary objective is to reveal the manner of growth of the dune size λ with the time t (i.e., the form of $\lambda = f(t)$ for $0 < t < T$). The bed topography is measured with the aid of an electronic bed plotter.

414-10522-220-90

ON THE TIME GROWTH OF RIPPLES FORMED BY AN OPEN CHANNEL FLOW

(*b*) National Research Council of Canada.
(*c*) Dr. M. S. Yalin.
(*d*) Mainly experimental (M.Sc. thesis); basic research.
(*e*) Completely analogous to the preceding topic. The difference is that sand waves were ripples (which are almost independent of the flow depth) rather than dunes (which vary almost in proportion to flow depth).

414-10523-220-90

FORCES ACTING ON THE BED FEATURES OF AN OPEN CHANNEL FLOW

(*b*) National Research Council of Canada.
(*c*) Dr. M. S. Yalin.
(*d*) Mainly experimental (M.Sc. thesis); basic research.
(*e*) A shear plate was constructed for a direct measurement of the fluid dynamic forces acting on the (rigid) bed features simulating the sand waves (ripples or dunes). Thus the longitudinal magnitude of this force and consequently the overall bed shear stress and the friction factor was obtained. These quantities were determined as certain (experimental) functions of the relative size of bed features, their steepness and the roughness of their surface.

414-10524-220-90

ON THE DISTRIBUTION OF SUSPENDED SEDIMENT IN TRANSITIONAL REGIONS

(*b*) National Research Council of Canada.
(*c*) Dr. M. S. Yalin.
(*d*) Theoretical and experimental (Ph.D. thesis); basic research.
(*e*) Consider a clear fluid entering a cohesionless mobile bed. As a result of the dynamic action of flow the suspended load will grow (from "zero" onwards) along the direction of flow in a manner analogous to the growth of the boundary layer thickness. A reverse process (the settlement of the existing suspended load) will take place after the abrupt termination of the mobile bed. The purpose of this investigation was to determine the variation of the "ceiling" of concentration distribution in the flow direction (x) for both of the cases mentioned. A laser-beam technique was used to measure the concentration profiles (in the glass walled laboratory flume).

414-10525-810-90

MAGNITUDE AND PROBABILITY OF PEAK FLOWS ON SMALL DRAINAGE BASINS IN SOUTHERN ONTARIO

(*b*) The National Research Council of Canada.
(*c*) Dr. W. E. Watt.
(*d*) Experimental and theoretical project; applied research for Masters and Doctoral theses.
(*e*) Determination of a technique for evaluating the peak discharge corresponding to a given return period and development of a simple, mathematical watershed model for small drainage basins.
(*h*) **SIMFLO–A Continuous Streamflow Simulation Model,** W. E. Watt, R. Bishop, *Proc. Canadian Hydrology Symp. 75*, Natl. Research Council of Canada, pp. 575-584, 1975.

414-10526-810-90

QUURM–QUEEN'S UNIVERSITY URBAN RUNOFF MODEL

(*b*) The National Research Council of Canada.
(*c*) Dr. W. Edgar Watt.
(*d*) Theoretical and field investigation towards M.Sc. degree.
(*e*) Calvin Park Urban Drainage Basin has been instrumented for rainfall, discharge and water quality. The Queen's University Urban Runoff Model (QUURM) has been developed and tested on a number of urban drainage basins in the simulation mode.
(*h*) **QUURM–A Realistic Urban Runoff Model,** W. E. Watt, C. H. R. Kidd, *J. Hydrology* **27**, pp. 225-235, 1975.
Hydrologic Effects of Urban Development, *Proc. Canadian Hydrology Symp. 75*, Natl. Research Council of Canada, pp. 708-717, 1975.
QUURM-Implications for the Design of Urban Drainage Basins, *Environmental Aspects of Irrigation and Drainage*, ASCE, pp. 580-592, 1976.

414-10527-290-90

STATIC ICE FORCES

(*b*) National Research Council of Canada.
(*c*) Professor S. S. Lazier.
(*d*) Basic theoretical work and experimental work in the field; directed toward M.Sc. and Ph.D. degrees.
(*e*) Temperature gradient with an ice sheet and internal stresses within an ice sheet have been measured in the field. An examination of the role played by cracks has been carried out both in the field and in the laboratory, and related to the practical sources which may be exerted on extended structures.
(*f*) Inactive.
(*h*) **Temperature Gradient in a Lake Ice Cover,** M. Metge, S. S. Lazier, *IAHR Ice Symp.*, Reykjavík, 1970, 5 pages.
Thermal Cracks in Lake Ice Sheets, M. Metge, S. S. Lazier, *IAHR Ice Symp.*, Leningrad, Sept. 1972, 5 pages.

Movements in Continuous Ice Sheets and Temperature Gradients in Ice Sheets, F. A. MacLachlan, S. S. Lazier, *Natl. Research Council of Canada Symp. in Snow and Ice*, Calgary, 1969.
Proposals for Measuring the Thickness of Ice Sheets, S. S. Lazier, M. Metge, *Eastern Snow Conf. Proc. 1973*, pp. 92-101.

414-10528-410-90

DYNAMIC EQUILIBRIUM PROFILES

(*b*) National Research Council.
(*c*) Dr. J. W. Kamphuis.
(*d*) Experimental and theoretical research toward M.Sc. and Ph.D. degrees.
(*e*) Dynamic equilibrium profiles resulting from simulated annual wave climates are studied. The work encompasses beach profiles as well as rubble mound breakwater profiles.
(*h*) **Placing Artificial Beach Nourishment,** J. W. Kamphuis, S. G. Bridgeman, *Civil Engrg. in the Oceans III*, pp. 197-216, Delaware, 1975.
Three Dimensional Tests on Dynamic Equilibrium and Artificial Nourishment, *Proc. 15th Conf. Coastal Engrg.*, Honolulu, 1976.

414-10529-410-90

ARTIFICIAL BEACH NOURISHMENT

(*b*) National Research Council.
(*c*) Dr. J. W. Kamphuis.
(*d*) Experimental and theoretical research toward M.Sc. and Ph.D. degrees.
(*e*) Time and location of placement of artificial beach nourishment has been studied. Sediment particle movements and littoral drift rates are being investigated. Effects of structures will be investigated.
(*h*) **Placing Artificial Beach Nourishment,** J. W. Kamphuis, S. G. Bridgeman, *Civil Engrg. in the Oceans III, pp. 197-216, Delaware, 1975.*
Three Dimensional Tests on Dynamic Equilibrium and Artificial Nourishment, *Proc. 15th Conf. Coastal Engrg.*, Honolulu, 1976.

414-10530-420-90

RUNUP OF IRREGULAR NON-BREAKING WAVES

(*b*) National Research Council.
(*c*) Dr. J. W. Kamphuis.
(*d*) Experimental and theoretical research toward M.Sc. degree.
(*e*) Runup on a smooth slope of Bretschneider and Scott spectra has been investigated.
(*f*) Completed.
(*h*) **Runup of Irregular Waves on a Smooth Slope,** J. W. Kamphuis, N. Mohamed, submitted for publication by *ASCE Waterways Proceedings.*

414-10531-470-90

MARINA AGITATION

(*b*) National Research Council.
(*c*) Dr. J. W. Kamphuis.
(*d*) Experimental and theoretical research toward M.Sc. and Ph.D. degrees.
(*e*) Short wave agitation of marinas is studied. The forcing function (wave action outside and entrance conditions), as well as the responding function (marina configuration, perimeter protection, arrangement of docks and piers, placement of boats, etc.), are studied individually and in combination.

414-10532-870-00

THE EFFECT OF SEDIMENTATION WITH CENTRIFUGAL FORCE ON THE ACTIVATED SLUDGE PROCESS

(*c*) Dr. J. D. Boadway.
(*d*) Experimental project for a Master's thesis.
(*e*) A device which clarifies fluids using centrifugal force produces a dense sludge and has low retention time. The project is to investigate how much the activated sludge process will benefit from the production of a sludge which is fresher than normal.

UNIVERSITY OF SASKATCHEWAN, Department of Mechanical Engineering, Saskatoon, Canada S7N OWO. Dr. P. R. Ukrainetz, Department Head.

415-07895-130-00

THE EFFECT OF SHOCK WAVE INTERACTION WITH AN ATOMIZED LIQUID JET

(*b*) DRB Canada.
(*c*) M. E. Stoneham, Associate Professor.
(*d*) Experimental, applied research.
(*e*) The mechanism of interaction of a shock wave with individual droplets and the effects upon droplet breakup that arise from the proximity of one droplet to another in one-dimensional arrays of droplets has been studied. The work has been undertaken as the first phase of a programme of investigation with the ultimate objective of determining the effects of shock waves on the breakup times and droplet sizes and droplet distributions in atomized liquid jets.
(*g*) Measurement of the breakup times of droplets in equally-spaced one-dimensional droplet arrays at pitches less than 3.0 times droplet diameter and subject to transverse shock waves indicate that significant reduction in breakup times may be expected compared with estimates given by models for single droplets.
(*h*) **The Aerodynamic Breakup of Droplets in an Array,** M. E. Stoneham, G. Raghavan, *Proc. Combustion Inst. Tech. Mtg.*, Banff, 1977.

415-10332-810-90

THERMODYNAMICS OF SNOWMELT

(*b*) NRCC, IWD/DOE, Canada.
(*c*) D. H. Male, Professor.
(*d*) Field investigation, applied research.
(*e*) Define as precisely as practicable the various climatological and topographical factors which influence the movement of water through snow and ice in a prairie environment. The first phase of this work is an investigation of the thermodynamics of snowmelt designed to establish the relative importance of the evaporation, convection and radiation energy fluxes to the melt process for the range of climatological conditions normally encountered during the spring melt season. This phase is near completion. The second phase of this work involves a study of melt rates when the snow cover is no longer continuous and bare patches appear. Major runoff events normally occur during this period and an attempt is being made to quantify the areal variability of melt rates under this condition.
(*h*) **Problems in Developing a Physically-Based Snowmelt Model,** D. H. Male, D. M. Gray, *Can. J. of Civil Eng.* **2**, pp. 474-488, 1975.
Energy Transfer in Snow, D. M. Gray, D. H. Male, *Tech. Memo. No. 114*, NRCC, pp. 28-43, 1974.
A Dimensional Analysis of Heat and Mass Transfer in a Snowpack, D. H. Male, D. I. Norum, R. W. Besant, *Proc. Intl. Symp. Role of Snow and Ice in Hydrology*, UNESCO, WMO, IAHS, pp. 258-290, 1973.

UNIVERSITY OF TORONTO, Department of Chemical Engineering and Applied Chemistry, Toronto, Ontario, Canada, M5S 1A4. Professor M. E. Charles, Chairman.

416-06950-050-00

IMPINGING JET STUDIES

(*c*) Dr. Olev Trass, Professor.

(*d*) Experimental and theoretical studies for graduate theses, basic research.
(*e*) Velocity profiles, turbulence and boundary layer development for liquid and gas jets impinging on flat surfaces. Pressure distributions and local mass transfer rates at the surface. Application to heat and mass transfer situations of academic as well as industrial interest.
(*f*) Main aspects completed.
(*g*) Theoretical solutions and experimental verification of flow, turbulence and wall mass transfer. General impingement region characterization model proposed. Initial study of mechanical erosion with and without diffusional mass transfer completed.
(*h*) **Mass Transfer from Crystalline Surfaces in a Turbulent Impinging Jet. Part I. Transfer by Erosion,** F. Giralt, O. Trass, *Can. Jour. of Chem. Eng.* **53**, pp. 505-511, 1975.
Mass Transfer from Crystalline Surfaces in a Turbulent Impinging Jet. Part II. Erosion and Diffusional Transfer, F. Giralt, O. Trass, *Can. Jour. Chem. Eng.* **54**, pp. 148-155, 1976.
Characterization of the Impingement Region in an Axisymmetric Turbulent Jet, F. Giralt, C. J. Chia, O. Trass, *Ind. Eng. Chem. Fundam.* **16**, 1, pp. 21-28, 1977.
Mass Transfer in Axisymmetric Turbulent Impinging Jets, C. J. Chia, F. Giralt, O. Trass, *Ind. Eng. Chem. Fundam.* **16**, 1, pp. 28-35, 1977.

416-06951-140-00

ROUGH SURFACE TRANSFER

(*c*) Dr. Olev Trass, Professor.
(*d*) Mainly experimental studies for graduate theses, basic research.
(*e*) Flow patterns and mass transfer at surfaces having various types and sizes of roughness. To elucidate influence of roughness patterns on momentum, heat and mass transfer.
(*g*) Some mass transfer results for random and regular V-groove roughnesses.
(*h*) **Mass Transfer at Rough Surfaces,** D. A. Dawson, O. Trass, *Intl. J. Heat Mass Transfer* **15**, pp. 1317-1336, 1972.

416-06952-710-00

FLOW VISUALIZATION STUDIES BY PHOTOCHROMIC DYE TECHNIQUE

(*c*) R. L. Hummel, Professor.
(*d*) Experimental, basic and applied research, for Ph.D., M.A.Sc., postdoctorals and technical assistants.
(*e*) The technique uses a dye indicator, for example 2-(2'4'-dinitrobenzyl) pyridine, which is converted from an almost colourless form to one which is deep blue by a beamed ultraviolet light. The light is generated by lasers, flash lamps, etc., in a collimated beam which can generate dye lines. The dye lines are followed photographically, and properties of the flow, such as velocity profiles are measured. The high speed automatic flow visualization computer "POLLY," is used to log and analyse the data.
(*h*) **Fluid Velocity Profiles Near the Wall of Liquid-Fluidized Beds,** B. G. Allen, J. W. Smith, *Can. J. Chem. Eng.* **41**, pp. 430-438, 1971.
Some Statistical Properties of Turbulent Momentum Transfer in Rough Pipes, S. G. Dunn, J. W. Smith, *Can. J. Chem. Eng.* **50**, pp. 561-568, 1972.
An Experimental Study of Instabilities and Other Flow Properties of a Laminar Pipe Jet, A. De P. Iribarne, F. Frantisak, R. L. Hummel, J. W. Smith, *AIChE J.* **18**, pp. 689-698, 1972.
Studies of Fluid Flow by Photography Using a Non-Disturbing Light-Sensitive Indicator, J. W. Smith, R. L. Hummel, *J. SMPTE* **82**, pp. 278-281, 1973.
Light-Induced Disturbances in the Photochromic Flow Visualization Technique, J. W. Smith, J. A. C. Humphrey, B. Davey, R. L. Hummel, *Chem. Eng. Science* **29**, pp. 308-312, 1974.
Determination of the Position of Visualized Material Elements in Growing Drops, J. A. C. Humphrey, R. L. Hummel, J. W. Smith, *Can. J. Chem. Eng.* **52**, pp. 110-113, 1974.
Mass Transfer Enhancement Due to Circulation in Growing Drops, J. A. C. Humphrey, R. L. Hummel, J. W. Smith, *Chem. Eng. Sci.* **29**, pp. 1496-1500, 1974.
Experimental Profiles in Laminar Flow Around Spheres at Intermediate Reynolds Number, L. E. Seeley, R. L. Hummel, J. W. Smith, *J. Fluid Mech.* **68**, p. 591, Apr. 1975.
Experimental Study of the Fluid Dynamics of Forming Drops, J. A. C. Humphrey, R. L. Hummel, J. W. Smith, *Can. J. Chem. Eng.* **52**, pp. 449-456, 1974.
Laminar Flow in the Central Plane of a Curved Circular Pipe, J. Kaczinsky, J. W. Smith, R. L. Hummel, *Can. J. Chem. Eng.* **53**, pp. 221-224, 1975.
Some Observations of Wake Behaviour in Laminar and Turbulent Free Stream Flow, L. E. Seeley, R. L. Hummel, J. W. Smith, *Proc. 4th Biennial Symp. Turbulence in Liquids*, Univ. of Missouri-Rolla, Sept. 1975.

UNIVERSITY OF TORONTO, Department of Mechanical Engineering, Toronto, Canada M5S 1A4. Professor David S. Scott, Department Chairman.

417-06817-360-00

TURBULENCE MEASUREMENTS IN WATER

(*b*) National Research Council of Canada.
(*c*) Professor H. J. Leutheusser.
(*d*) Experimental; basic research.
(*e*) Evaluation of turbulence parameters in hydraulic jump.
(*f*) Completed.
(*g*) Measurements of turbulence characteristics, air entrainment and flow separation reveal significant effects of condition of inflow onto flow inside jump body.
(*h*) **Hydraulic Jump in a Rough Channel,** H. J. Leutheusser, E. J. Schiller, *Intl. Water Power and Dam Construction* **27**, 5, pp. 186-191, May 1975.
Thermodynamic Aspects of Hydraulic Aeration, H. J. Leutheusser, C. A. Ward, *Proc. XVIth Congress of IAHR*, Sao Paulo, Brazil, 1975.
Entrainment d'Air et Réaération en Écoulement Hydraulique, F. J. Resch, H. J. Leutheusser, C. A. Ward, *Proc. Symp. Grenoble, IAHR*, Grenoble, France, 1976.
Etude de la Structure Cinématique et Dynamique du Ressaut Hydraulique, J. F. Resch, H. J. Leutheusser, M. Coantic, *J. Hydr. Research* **14**, 4, pp. 293-319, 1976.

417-07461-240-00

AERODYNAMIC OSCILLATIONS OF BLUFF CYLINDERS

(*b*) National Research Council of Canada.
(*c*) Professor I. G. Currie.
(*d*) Experimental, basic research (but has applications) for Master's thesis.
(*e*) Establish the effect of "mass ratio" on vortex-induced oscillations. That is, it is intended to answer the question "do heavy cylinders in air behave differently from light cylinders in water?"

417-07899-010-00

BOUNDARY LAYER SEPARATION ON BLUFF BODIES

(*b*) National Research Council of Canada.
(*c*) Professor I. G. Currie.
(*d*) Experimental basic research for Master's thesis.
(*e*) Make refined measurements in the vicinity of a laminar separation point in order to obtain a better understanding of the physics of the flow. This is being attempted by use of a laser Doppler anemometer with a flow around a bluff body having a stabilized wake.

417-07903-020-00

INTERMITTENCY IN TURBULENT FLOWS

(*b*) National Research Council of Canada.
(*c*) Professor James F. Keffer.
(*d*) Basic research, experimental and theoretical.
(*e*) Continuing investigation of the properties of the turbulent/non-turbulent interface at the free edge of shear flows, e.g., boundary layers, wakes, jets and mixing layers. On-line digital sampling and processing techniques are used. Passive contaminants are used to help identify the turbulent field.
(*g*) Generalized method for deciding when fluid motion is turbulent has been studied. Improved detector functions have been derived as a result. Techniques have been applied to a turbulent boundary layer, thermal mixing layer, hot wake and hot jet.
(*h*) **Intermittency in a Thermal Mixing Layer,** J. F. Keffer, J. G. Kawall, G. J. Olsen, *J. Fluid Mech.* **79,** pp. 595-607, 1977.
Intermittency Measurements in Contaminated Turbulent Flows, J. F. Keffer, *Arch. of Mech.* **28,** pp. 911-921, 1976.
Spread of a Heated Plane Turbulent Jet, A. E. Davies, J. F. Keffer, W. D. Baines, *Phys. of Fluids* **18,** pp. 770-775, 1975.
Entrainment by a Multiple Source Turbulent Jet, W. D. Baines, J. F. Keffer, *Advances in Geophysics* **18B,** pp. 289-298, 1974.

417-07904-480-00

WIND STRUCTURE OVER URBAN AREAS

(*c*) Professor James F. Keffer.
(*d*) Basic research, experimental and theoretical, field study.
(*e*) Digital sampling and processing of data taken from field stations are used to determine the large-scale structure of wind generated by large buildings. Field sites are chosen so that multi-point, spacetime correlation techniques can be used.
(*g*) Preliminary results show a shift of energy in power spectrum from high to low wave numbers.

417-09595-060-00

VERY HEAVY OR VERY LIGHT PLUMES

(*b*) National Research Council of Canada.
(*c*) Professor W. D. Baines.
(*d*) Experimental and theoretical.
(*e*) Buoyant plumes such as are produced by hot sources in steel foundries and gravity currents such as are produced by snow movements have the characteristics in common that the variations in density are of the same order as the density and hence the Boussinesq approximation cannot be used in an analysis. The rate of entrainment depends on both the velocity and density of the free turbulent flow. Studies are under way to determine the effect of large density differences.
(*g*) Numerical solutions using different assumptions for entrainment have been obtained. Experimental verification of these solutions has not been achieved.
(*h*) **Non-Boussinesq Forced Plumes,** P. F. Crapper, W. D. Baines (in press).
A Note on Forced Plumes with Negative Buoyancy, P. F. Crapper, W. D. Baines (in press).

417-09597-020-87

SPREAD OF HEAT AND MOMENTUM IN ASYMMETRICAL TURBULENT FLOWS

(*b*) Institut de Mecanique Statistique de la Turbulence, Marseille, France and National Research Council of Canada.
(*c*) Professor James F. Keffer.
(*d*) Basic research, experimental and theoretical.
(*e*) Examination of spread of contaminants in free turbulent shear flows with asymmetrical velocity and temperature profiles. Experiments being carried out in mixing layer with jump in temperature and an asymmetrical, partially heated jet.
(*g*) It has been found for the velocity case of an asymmetric wake flow that a relatively large region of "negative production of turbulence" exists. For the case of a partially heated mixing layer the equivalent thermal situation is found also.
(*h*) **Interpretation of Negative Production of Temperature Fluctuations by Spectral Analysis,** C. Béguier, L. Fulachier, J. F. Keffer, *Proc. Symp. on Turb. Shear Flows*, Penn. State, 1977.
Etude Spectrale d'un Ecoulement a Production Negative des Fluctuations Turbulentes de Température, C. Béguier, L. Fulachier, J. F. Keffer, *Comptes Rendus*, Sér. B, p. 417, 1976.
Production de Turbulence des Fluctuations de Vitesse en de Température dans les Ecoulements à Profile Moyens Dissymétriques, C. Béguier, L. Fulachier, J. F. Keffer, *J. de Physique* **37,** C1-187, 1976.
Epanouissement d'un Crénau de Chaleur dans une Zone de Mélange Turbulent, C. Béguier, L. Fulachier, J. F. Keffer, R. Dumas, *Comptes Rendus*, Sér. B, p. 493, 1975.
Production Négative de Fluctuations Turbulentes de Température dans le Cas d'un Créneau de Chaleur s'Epanouissant dans une Zone de Mélange, J. F. Keffer, L. Fulachier, C. Béguier, *Comptes Rendus*, Sér. B, p. 519, 1975.

417-09598-020-90

DISTORTION OF TURBULENT SHEAR FLOWS

(*b*) National Research Council of Canada.
(*c*) Professor James F. Keffer.
(*d*) Basic research, experimental and theoretical.
(*e*) Examination of gross uniform strain applied to various shear flows, e.g., wakes and mixing layers.
(*g*) Results for a thermal mixing layer indicate that the self-preserving scales do not follow the predicted variation.
(*h*) Doctoral thesis in preparation.

417-09599-210-00

SKIN FRICTION IN UNSTEADY FLOW

(*b*) National Research Council of Canada.
(*c*) Professor H. J. Leutheusser.
(*d*) Basic research, experimental and theoretical.
(*e*) Study of the mechanics of energy dissipation in transient flow.
(*g*) U-tube oscillations and establishment-in-time of pipe flow have been studied both experimentally and analytically. Results indicate conclusively that the standard techniques for approximating transient skin friction effects lead to erroneous results.
(*h*) **Skin Friction in Unsteady Laminar Pipe Flow,** M. F. Letelier, H. J. Leutheusser, *J. Hydr. Div., ASCE* **102,** HY1, pp. 41-56, 1976.
Laminar-to-Turbulent Transition in Accelerated Fluid Motion, H. J. Leutheusser, K. W. Lam, *Proc. XVIIth Congress of IAHR*, Baden-Baden, Germany, 1977.

417-10502-000-90

PLANE COUETTE FLOW

(*b*) National Research Council of Canada.
(*c*) Professor H. J. Leutheusser.
(*d*) Experimental and theoretical, basic research.
(*e*) A fundamental investigation of the structure of turbulence in a uniformly sheared flow with and without wall roughness is being undertaken. The Couette principle will also be applied to a study of the initial steps in surface-wave generation by applying a known shear stress to a water surface.

417-10503-250-90

EXTENSIONAL FLOWS OF DILUTE POLYMER SOLUTIONS

(*b*) National Research Council of Canada.
(*c*) Professor D. F. James.

(*d*) Experimental, basic research.
(*e*) Dilute polymer solutions, with concentrations in the drag-reducing regime, are being studied for the case of flow through small orifices. Measurements of flow rate and pressure drop, reveal that the departure from Newtonian behaviour is generally sudden, appreciable, and concurrent with the onset of an unstable secondary flow pattern.

417-10504-250-90

MECHANICAL MODELS OF DISSOLVED MACROMOLECULES IN CONVERGING FLOWS

(*b*) National Research Council of Canada.
(*c*) Professor D. F. James.
(*d*) Theoretical, basic research for Master's thesis.
(*e*) The validity of the Rouse model for macromolecules is examined for radially converging flows of dilute polymer solutions, that is, flows in a wedge or cone. The analysis shows that the Rouse model is valid and that the molecules do not cause any significant departure from Newtonian behaviour. A model having finite extension is proposed and is shown to produce large non-Newtonian stresses.
(*f*) Analysis complete; thesis in preparation (H. King).

417-10505-210-70

SIMULATION OF WATERHAMMER

(*b*) Canadian Johns-Manville Co. Ltd.
(*c*) Professor D. F. James.
(*d*) Experimental; design of test procedure.
(*e*) A method was developed to test 12-inch cement-asbestos pipes for the sudden pressure loads that can be produced by waterhammer. The pressure history due to waterhammer was simulated by subjecting test lengths of pipe, filled with water, to suddenly released gas pressure. This technique produced a pressure jump in 0.2 seconds. The pressure jump was raised until a pipe burst.
(*f*) Work completed, report submitted to sponsor.
(*g*) Cement-asbestos pipes can sustain a higher pressure applied suddenly than applied quasi-statically.

417-10506-130-90

PRESSURE FLUCTUATIONS IN TWO-PHASE FLOW

(*b*) National Research Council of Canada; Institut fuer Hydromechanik, Universitaet Karlsruhe, Germany.
(*c*) Professor H. J. Leutheusser.
(*d*) Experimental, basic research for Master's thesis.
(*e*) It is known that the occurrence of two-phase flow in hydraulic systems tends to render fluctuating forces more intense and regular. It is planned to study the fundamental physical processes involved in this transformation.

417-10507-010-90

BOUNDARY LAYER BEHAVIOUR ON A CIRCULAR CYLINDER IN CRITICAL REYNOLDS-NUMBER RANGE

(*b*) National Research Council of Canada.
(*c*) Professor W. W. Martin.
(*d*) Experimental, basic research for graduate thesis.
(*e*) Boundary layers on fixed and oscillating cylinders are investigated in critical Reynolds-number range to high blockage (3) using hot-wire anemometry. The aim of the project is to investigate the possibility of self-induced oscillations.
(*g*) Data on the formation and collapse of a separation "bubble" in critical Reynolds-number range have been obtained for a fixed cylinder and correlated with drag coefficient, Strouhal number and spectral analysis of boundary layer and wake fluctuations.

417-10508-000-00

FLOW OVER A RECTANGULAR CAVITY

(*b*) National Research Council of Canada.
(*c*) Professor W. W. Martin.
(*d*) Experimental and theoretical.
(*e*) The free shear flow across the cavity is studied using laser Doppler anemometry to measure the development with downstream position. The nature of the fluid dynamic feedback which occurs for some flow conditions is being considered.

TRENT UNIVERSITY, Department of Geography, Peterborough, Ontario, Canada K9J 7B8. Dr. A. G. Brunger, Chairman.

418-10618-810-90

SNOWFALL AND SNOWCOVER IN THE PETERBOROUGH AREA

(*b*) Environment Canada.
(*c*) Dr. W. P. Adams.
(*d*) Field investigation.
(*e*) Studies of methods of measuring snowfall; areal distribution and stratigraphy of snowcover.
(*h*) **Areal Differentiation of Snowcover in East Central Ontario,** W. P. Adams, *Water Resources Res.* **12,** 6, pp. 1226-1234, 1976.
Limitations of the Bulk Density Method of Snow Course Measurement and the Need for More Detailed Snow Data, W. P. Adams, *J. of Soil and Water Conservation* (in press).

418-10619-440-90

SNOW AND ICE COVER OF LAKES

(*b*) National Research Council of Canada, Environment Canada.
(*c*) Dr. W. P. Adams.
(*d*) Field investigation, includes graduate research.
(*e*) A study of the growth and decay of the winter cover of lakes with some reference to the biological roles of that cover.
(*h*) **Field Determination of the Densities of Lake Ice Sheets,** W. P. Adams, *Limnology and Oceanography* **21,** 4, pp. 602-608, July 1976.
Approaches to the Study of Ice-Push Features, with Reference to Gillies Lake, Ontario, W. P. Adams, S. A. Mathewson, *Rev. Geogr. Montr.* **XXX,** 1-2, pp. 187-196, 1976.
Diversity of Lake Cover and Its Implications, W. P. Adams, *Musk-Ox* **18,** pp. 86-96, 1976.

418-10620-810-90

EFFECTS OF URBANIZATION ON STREAMFLOW, PETERBOROUGH, ONTARIO

(*b*) National Research Council of Canada.
(*c*) Dr. C. H. Taylor.
(*d*) Field investigation; M.Sc. thesis in progress.
(*e*) A study of the effects of on-going suburban development on the runoff response and sediment yield of a small stream in Peterborough, Ontario.
(*f*) The study has been on-going since 1973.
(*g*) Results indicate that suburban development has increased peak discharges and direct runoff volumes significantly, and that the magnitude of the effect varies seasonally.
(*h*) **Effects of Suburban Development on Streamflow in a Small Basin in Peterborough, Ontario,** C. H. Taylor, *Proc. 9th Canadian Hydrology Symp.*, Winnipeg, Aug. 11-14, 1975, pp. 745-750.
Seasonal Variations in the Impact of Suburban Development on Runoff Response: Peterborough, Ontario, C. H. Taylor, *Water Resour. Res.* **13,** 2, pp. 464-468, 1977.

418-10621-810-90

RUNOFF PRODUCTION IN A SMALL SWAMP NEAR PETERBOROUGH, ONTARIO

(*b*) National Research Council of Canada.
(*c*) Dr. C. H. Taylor.
(*d*) Field investigation; M.Sc. thesis in progress.

(*e*) This study is an investigation of the processes that control the runoff response of a small swamp-fed stream. Particular attention is being paid to the applicability of the variable source area model, by relating seasonal and storm-to-storm fluctuations in the extent of the saturated area to the runoff response. Both snowmelt and rainstorm events are included.
(*g*) Field data have been collected for two seasons and are currently being analysed. Preliminary indications are that fluctuations in swamp area, related to variations in the local water table, are the dominant control of the runoff response.

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UNIVERSITY OF WATERLOO, Department of Civil Engineering, Waterloo, Ontario, Canada N2L 3G1.

419-09605-310-00

RESERVOIR OPERATION DURING FLASH FLOODS

(*c*) Professor N. Kouwen.
(*d*) Field investigation, applied research.
(*e*) The work examines the utility of a direct access computer program with radar precipitation inputs in forecasting stream flow during flash floods.
(*h*) **Radar and Direct Access Computers in Flood Control,** *Meeting Preprint 2594*, *ASCE*, Nov. 3-7, 1977.

419-09607-210-00

SLAMMING OF HYDRAULIC CHECK VALVES

(*c*) Professors N. Kouwen and David Weaver of McMaster University, Hamilton, Ontario, Canada.
(*d*) Theoretical and experimental; thesis.
(*e*) Methods are sought to reduce the harmful effects of slamming of closing check valves in water lines.
(*f*) Completed.
(*h*) **Flow Induced Vibrations of a Hydraulic Valve and Their Elimination,** D. S. Weaver, F. A. Adubi, N. Kouwen, *Fluids Engrg. and Bioengrg. Conf.*, *ASME*, New Haven, Conn., June 15-17, 1977.

419-09608-860-00

WATER QUALITY BEHAVIOR IN ICE COVERED RIVERS

(*c*) Professors E. McBean and G. J. Farquhar.
(*d*) Theoretical and field investigation; thesis.
(*e*) The changes in velocity profile, the potential alteration in depositional patterns and the effects of breaks in ice covers are a few of the factors which preclude direct utilization of non-ice relationships in the presence of ice. The intent of this research is to identify, and define, the role of the essential features affecting the water quality response under ice.

419-10509-400-90

NUMERICAL MODELING IN HUDSON BAY AND IN CHESTERFIELD INLET

(*b*) Environment Canada (Marine Sciences Directorate).
(*c*) Professor T. E. Unny.
(*d*) Finite difference modeling using implicit scheme and sparse matrix techniques.

419-10510-440-00

DISPERSION MODELS FOR LAKES

(*c*) Professors G. J. Farquhar and N. Kouwen.
(*d*) Theoretical and experimental; thesis.
(*e*) Methods are sought to physically model dispersion in lakes using distorted hydraulic models. A mathematical finite element model is used to interpret the results of measurements in a simple laboratory model.

419-10511-290-90

STOCHASTIC MODELING OF FLOWS IN HYDRAULICS

(*b*) National Research Council, Canada.
(*c*) Professor T. E. Unny.

418-10512-070-90

CONTAMINANT MIGRATION IN POROUS MEDIA

(*b*) Environment Canada and Ontario Ministry of the Environement.
(*c*) Professors G. J. Farquhar and J. F. Sykes.
(*d*) Experimental and field investigations; applied research.
(*e*) Research examines contaminant interactions through laboratory experimentation. Purpose is to express them in model format in order to enable the simulation of field behaviour.
(*g*) Excellent agreement has so far been achieved between laboratory and field methodologies for conservative and simple nonconservative contaminant species.

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WESTERN CANADA HYDRAULIC LABORATORIES LTD., 1186 Pipeline Road, Port Coquitlam, B. C., Canada V3B 4S1. Mr. Duncan Hay, Managing Director.

420-10533-430-90

HYDRAULIC MODEL STUDIES OF CAPE TORMENTINE FERRY TERMINAL BREAKWATER MODIFICATIONS

(*b*) Transport Canada, Marine & Ferry Branch, Ottawa, Ontario.
(*d*) Experimental for design and operation.
(*e*) Determine the effects of several alternative modifications to the existing harbour and pressured ice in the harbour area.
(*f*) Completed.

420-10534-470-90

ASSESSMENT OF FLUSHING CHARACTERISTICS OF SMALL HARBOURS, PHASE I

(*b*) Small Craft Harbours Branch, Pacific Region, Vancouver, B.C.
(*d*) Field investigation.
(*e*) To prepare guidelines for the study of flushing in small craft harbours and to introduce predictive techniques whereby potential flushing characteristics under varying situations can be evaluated.
(*f*) Completed.

420-10535-350-73

HYDRAULIC MODEL STUDIES OF RIVER DIVERSION AT PEACE RIVER SITE I

(*b*) British Columbia Hydro and Power Authority.
(*d*) Experimental for design and operation.
(*e*) Investigation of Phase B of the river diversion sequence during construction of the facilities at Site 1 on the Peace River including approach conditions, structure rating and performance, optimum Phase A cofferdam excavations, scour potential downstream of the structures, and cavitation potential at the structure gate slots.
(*f*) Completed.

420-10536-210-75

HYDRAULIC MODEL STUDIES OF SOROAKO HOWELL-BUNGER VALVE

(*b*) Canadian Bechtel Limited.
(*d*) Experimental for design and operation.
(*e*) Investigate approach flow conditions to proposed Howell-Bunger valve locations as an aid in assessing the structural adequacy of the valves. These valves are to be used to control discharge through "water saving synchronous by-passes" in the Lamingko powerhouse of the Larona Hydro Development, Soroako Nickel Project, Sulawesi, Indonesia.
(*f*) Completed.

420-10537-350-73

HYDRAULIC MODEL STUDY, PEACE RIVER–SITE I. DIVERSION GATE STUDIES

(*b*) British Columbia Hydro and Power Authority.
(*d*) Experimental for design and operation.
(*e*) Determine the hydraulically induced forces on one of the 19 ft by 40 ft diversion sluice gates during closure. Modify the gate to reduce excessive downpull force or control dynamic instability.
(*f*) Completed.

420-10538-340-73

COMPREHENSIVE HYDRAULIC MODEL STUDY, INTEGRATED POWERPLANT LIMESTONE GENERATING STATION

(*b*) Manitoba Hydro.
(*d*) Experimental for design and operation.
(*e*) This study was the final in a series of three: Sectional, gate and comprehensive models, to develop the integrated powerplant concept for the Limestone Site. The purpose was modified to generate data which could be applied to other sites.
(*f*) Completed.

420-10539-430-90

HYDRAULIC MODEL STUDIES OF TIRE-FILLED, CONCRETE WALL, AND CAISSON–TYPE FLOATING BREAKWATERS

(*b*) Department of Environment, Canada.
(*d*) Experimental for design and operations.
(*e*) Study undertaken to obtain floating breakwater efficiency data for tire-filled, thin wall, and caisson-type breakwaters, and to compare efficiency data of other floating breakwaters.
(*f*) Completed.

420-10540-340-75

HYDRAULIC MODEL STUDIES OF EMERGENCY COOLING SYSTEM PUMP INTAKE, DAVIS BESSIE NUCLEAR POWER STATION

(*b*) Bechtel Corporation, U.S.A.
(*d*) Experimental for design and operation.
(*e*) Investigate whether flow-reducing or air-entraining vortices would develop in the sump inlet of the emergency core cooling system, and to develop modifications for the elimination of vortices. Later modifications were introduced.
(*f*) Completed.

420-10541-340-75

HYDRAULIC MODEL STUDIES OF THE EMERGENCY COOLING SYSTEM INTAKES, J. M. FARLEY NUCLEAR POWER STATION

(*b*) Bechtel Corporation, U.S.A.
(*d*) Experimental for design and operation.
(*e*) The purpose was to investigate whether flow-reducing and air-entraining vortices would develop in the intakes and to develop modifications for the elimination of vortices. Modifications were introduced.

420-10542-350-70

HYDRAULIC MODEL STUDIES OF SKINS LAKE SPILLWAY, NECHAKO-KITIMAT PROJECT

(*b*) Aluminum Company of Canada Ltd.
(*d*) Experimental for design and operation.
(*e*) The studies were to assess the hydraulic performance of a new spillway and test any necessary modifications. Measurement of hydraulic forces was taken to aid in the selection of hoisting equipment.
(*f*) Completed.

420-10543-470-70

HYDRAULIC MODEL STUDIES OF HORSESHOE BAY FERRY TERMINAL, BERTH NO. 1

(*b*) Department of Highways and Public Works, B.C.
(*d*) Field investigation, and experimental design and operation.
(*e*) Determine the most economical means of protecting floats from ferry wash and debris caused by the propwash of the new 457 ft long ferries.
(*f*) Completed.

420-10544-340-70

PALO VERDE NUCLEAR GENERATION STATION

(*b*) Boving Division-Axel Johnson Corporation.
(*d*) Experimental for design and operation.
(*e*) Improve flow conditions to pumps.

420-10545-300-90

ANALYTICAL AND HYDRAULIC MODEL STUDIES, LOWER FRASER RIVER

(*b*) Department of Public Works, Canada.
(*d*) Experimental for design and operation.
(*e*) Investigate the feasibility of establishing 40 ft navigable depths on the lower Fraser River. The studies were divided into analytical studies, fixed bed hydraulic model studies, and movable bed hydraulic model studies.
(*f*) Completed.

420-10546-420-75

HYDRAULIC MODEL STUDIES OF TAILING DELTA STABILIZATION

(*b*) Klohn Leonoff Consultants Ltd., Vancouver, B.C.
(*d*) Experimental for design and operation.
(*e*) Determine the foreshore characteristics required to achieve stable conditions for given rock sizes under attack by a given wave height, and to study the general mechanism of longshore movement and beach development.
(*f*) Completed.

420-10547-470-96

WIND AND WAVE STUDIES OF THE PROPOSED GABRIOLA ISLAND FERRY TERMINAL

(*b*) Department of Highways, B.C.
(*d*) Field investigations and analytical studies.
(*e*) To conduct wind, wave and current studies of the proposed ferry terminal and the assessment of protection requirements at several potential sites.
(*f*) Completed.

420-10548-340-75

HYDRAULIC MODEL STUDIES OF TURBINE MANIFOLD, TALSTON 4 MW EXTENSION, NORTHERN CANADA COMMISSION

(*b*) W. F. Kelly and Associates Ltd., B.C.
(*d*) Experimental for design and operation.
(*e*) Examine by physical modeling the flow distribution from a four-unit flow distribution manifold to the turbine units under equal unit back pressures with and without splitter plates. Further modifications were introduced to improve flow conditions.
(*f*) Completed.

420-10549-390-70

CONCEPTUAL HYDRAULIC DESIGN OF OUTFALL PIPELINE SYSTEM, ISLAND COPPER MINE

(*b*) Utah Mines Ltd.
(*d*) Theoretical for design and operations.
(*e*) The preparation of a conceptual hydraulic design of tailings outfall system.
(*f*) Completed.

420-10550-300-65

HYDRAULIC MODEL STUDIES ON DON AND LION ISLANDS DEVELOPMENT, FRASER RIVER

(*b*) Rivtow Straits Limited, B.C.
(*d*) Experimental for design and operation.
(*e*) Evaluate the feasibility and effects of proposed causeways connecting Don and Lulu Islands, Don and Lion islands; to determine an optimum design for the improvement of alignment and location of the causeways; to determine the effectiveness of the tide in flushing pollutants from the backwater regions of the proposed development.
(*f*) Completed.

420-10551-410-96

STUDY OF THE CLIFF AND FORESHORE STABILIZATION PROBLEM AT POINT GREY, VANCOUVER

(*b*) Vancouver Board of Parks and Public Recreation.
(*d*) Field investigation.
(*e*) Review of all aspects of the Point Grey stabilization problem employing information from previous studies and other sources of available data in order to provide recommendations for immediate and long term actions.
(*f*) Completed.

420-10552-420-73

HYDRAULIC MODEL STUDIES OF QUANICASSEE UNITS 1 AND 2

(*b*) Bechtel Power Corporation.
(*d*) Experimental for design and operation.
(*e*) Investigate three-dimensional wave characteristics associated with the design storm for the Quanicassee Units 1 and 2 Power Plant.
(*f*) Suspended.

420-10553-350-73

HYDRAULIC MODEL STUDIES OF SPILLWAY DIVERSION STRUCTURE, LIMESTONE GENERATING STATION

(*b*) Manitoba Hydro.
(*d*) Experimental for design and operation.
(*e*) Evaluate the performance of the spillway, potential erosion, diversion ports and the hydraulic forces on the diversion gates.

420-10554-220-90

ANALYSIS OF SEDIMENT DATA TAKEN ON THE LOWER FRASER RIVER

(*b*) Department of Supply and Services.
(*d*) Field investigation.
(*e*) Define bivariate linear and nonlinear relations between hydraulic and sediment parameter, sediment-rating curves. Furthermore, it would determine multivariate sediment transport functions for the determination of total bed material in washload transport, and generate bedload measurement techniques based on the regime channel geometry.

420-10555-390-75

HYDRAULIC MODEL STUDIES OF KITIMAT ARM SLIDE

(*b*) Hecate Straits Engineering Ltd.
(*d*) Experimental for basic research.
(*e*) Determine the effects of submarine slide on the surrounding areas at Kitimal Port.

420-10556-850-90

HYDRAULIC MODEL STUDIES OF FISH TRANSFER FISH PUMP

(*b*) Department of Fisheries and Environment.
(*d*) Experimental for design and operation.
(*e*) Examine the performance of discreet peripheral jet pump in combination with air-lift pump in a typical fish pumping application.

420-10557-350-73

HYDRAULIC MODEL STUDIES OF REVELSTOKE PROJECT, COLUMBIA RIVER, B.C.

(*b*) B. C. Hydro and Power Authority.
(*d*) Experimental for design and operation.
(*e*) Evaluate on two separate models the diversion tunnel with appertenant structures with respect to approach conditions, structure performance, hydraulic loadings, tailwater levels, scour potential and operating procedures over a range of discharges.

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THE UNIVERSITY OF WESTERN ONTARIO, Department of Applied Mathematics, Faculty of Science, Engineering and Mathematical Sciences Building, London, Ontario, Canada N6A 5B9. Professor S. C. R. Dennis, Department Chairman.

421-07995-030-90

TIME DEPENDENT AND STEADY VISCOUS FLUID FLOW

(*b*) National Research Council of Canada.
(*c*) Professor S. C. R. Dennis.
(*d*) Theoretical.
(*e*) A number of studies of various flow configurations involving viscous fluids are under way. The objects of the project are to understand the physical nature of the flows concerned, and also to develop numerical techniques of solving the Navier-Stokes equations. Most of the recent work has been on steady flow in curved tubes. A major project on flow near rotating spheres is also being carried out in conjunction with Dr. S. N. Singh of the University of Kentucky, Lexington, Kentucky, U.S.A.
(*h*) **Application of the Series Truncation Method to Two-Dimensional Internal Flows,** S. C. R. Dennis, *Lecture Notes in Physics* **35,** pp. 138-143, 1975.
The Steady Motion of a Viscous Fluid in a Curved Tube, S. C. R. Dennis, W. M. Collins, *Quart. J. Mech. Appl. Math.* **28,** pp. 165-188, 1975.
Viscous Eddies Near a 90° and a 45° Corner in Flow Down a Curved Tube of Triangular Cross-Section, S. C. R. Dennis, W. M. Collins, *J. Fluid Mech.* **76,** pp. 417-432, 1976.
Steady Flow in a Curved Tube of Triangular Cross-Section, S. C. R. Dennis, W. M. Collins, *Proc. Roy. Soc. A.* **352,** pp. 189-211, 1976.
A Numerical Method for Calculating Steady Flow Past a Cylinder, S. C. R. Dennis, *Lecture Notes in Physics* **59,** pp. 165-172, 1977.

421-07996-020-90

DIFFUSION IN FLUID FLOWS

(*b*) National Research Council of Canada.
(*c*) Dr. P. J. Sullivan.
(*d*) Theoretical and experimental.
(*e*) A study of both mean and fluctuating concentration values of contaminant in incompressible flow fields is being undertaken. The concept of a local value of longitudinal diffusivity was explored both theoretically and experimentally for a uniformly bound turbulent shear flow and this is currently being extended to the situation in which the flow is inhomogeneous in the streamwise direction. In a simultaneous study of both the dispersion and diffusion problem in a general incompressible flow from an instantaneous source of contaminant, some significant progress is being made.
(*h*) **The Approach to the Final Stage of Dispersion in Turbulent Pipe Flow,** R. Dewey, P. J. Sullivan, *Trans. CSME* 3, 1, 1975.
The Maximum Value of Concentration When a Pulse is Dispersed in an Open-Channel Flow, P. J. Sullivan, *Trans. CSME* 3, 2, p. 90, 1975.

The Approach to Normality of the Distance-Neighbour Function When Used to Describe Relative Turbulent Diffusion, P. J. Sullivan, *ZAMP* **27,** p. 727, 1976.
Laminar Free Convection Due to a Point Source of Buoyancy, P. J. Sullivan, P. J. Sutherland, *ZAMP* **27,** p. 671, 1976.
Dispersion of a Line Source in Grid Turbulence, P. J. Sullivan, *Physics of Fluids* **19,** 1, 1976.
The Asymptotic Stage of Longitudinal Turbulent Dispersion Within a Tube, R. Dewey, P. J. Sullivan, *J. Fluid Mech.* **19,** 2, 1, 1977.

421-07997-010-90

THREE-DIMENSIONAL BOUNDARY LAYER THEORY

(*b*) National Research Council of Canada.
(*c*) Dr. M. Zamir.
(*d*) Theoretical.
(*e*) The work is aimed at a reconstruction of boundary layer theory so as to accommodate three-dimensional boundary layers within its scope. The main feature of the approach is the use of tensor analysis to rederive the boundary layer equations in a form which is independent of the coordinate system. Three-dimensional boundary layers are of utmost importance since they arise in a wide variety of practical situations such as the flow in rivers and channels of non-circular cross-section.
(*h*) **On The Corner Boundary Layer With Favourable Pressure Gradient,** *Aeronaut. Quart.* **XXIII,** 1972.
Further Solution of the Corner Boundary Layer Equations, *Aeronaut. Quart.* **XXIV,** 1973.

421-09634-400-00

THEORETICAL STUDY OF THE SALINITY AND FLOW PATTERN IN ESTUARIES

(*c*) Dr. H. Rasmussen.
(*d*) Theoretical.
(*e*) A theoretical study of the salinity distribution and the general flow pattern in estuaries is in progress. An approximate steady two-dimensional model has been derived for slightly stratified estuaries and is now being analysed using Galerkin's method.
(*h*) **On Flow in Estuaries, Part I. A Critical Review of Some Studies of Slightly Stratified Estuaries,** H. Rasmussen, J. B. Hinwood, *La Houille Blanche* **209,** pp. 377-395, 1972. **Part II. A Slightly Stratified Turbulent Flow,** *La Houille Blanche* **209,** pp. 396-407, 1972. **Part III, Derivation of General and Breadth Integrated Models,** *La Houille Blanche* **212,** pp. 319-337, 1973.

421-10558-820-90

NUMERICAL STUDY OF FREE-SURFACE GROUNDWATER FLOW

(*b*) National Research Council of Canada.
(*c*) Dr. H. Rasmussen.
(*d*) Theoretical.
(*e*) Free-surface flow is modeled by Laplace equation for the velocity potential and nonlinear first-order partial differential equation for the free surface. The potential problem is reformulated as a variational problem and then solved approximately by a Rayleigh-Ritz expansion. The free-surface equation is solved using finite differences.

UNIVERSITY OF WINDSOR, Department of Mechanical Engineering, Windsor, Ontario, Canada. Professor W. G. Colborne, Chairman, Graduate Studies, Department of Mechanical Engineering.

422-09635-290-90

DIFFUSERS WITH INLET SWIRL

(*b*) National Research Council of Canada.
(*c*) Dr. K. Sridhar.
(*d*) Theoretical; basic research for Ph.D.
(*e*) The work done so far on diffusers is experimental. The aim is now to develop an analytical method for flows in diffusers with inlet swirl.
(*h*) **Effect of Inlet Swirl and Wall Layer Thickness on the Performance of Equiangular Annular Diffusers,** R. Coladipietro, *M.A.Sc. Thesis,* Univ. of Windsor, 1974.
Effects of Inlet Flow Conditions on the Performance of Equiangular Annular Diffusers, R. Coladipietro, J. H. Schneider, K. Sridhar, *Paper No. 73-CSME-84, CSME-ASME Fluids Engrg. Conf.,* Montreal, May 1974. Also published in *Trans. CSME* **3,** 2, pp. 75-82, 1975.

422-09636-600-90

BISTABLE FLUIDIC AMPLIFIERS

(*b*) National Research Council of Canada.
(*c*) Professor W. G. Colborne.
(*d*) Experimental, basic research for bistable amplifiers. The mechanism of switching in a bistable amplifier is also being studied by investigating the characteristics of the separation bubble. By developing an accurate model it is hoped that accurate predictions of switching time can be made for a variety of configurations and flows.
(*h*) **Splitter Switching in Bistable Fluidic Amplifiers,** C. J. Williams, W. G. Colborne, *CSME Paper No. 73-CSME-83, EIC Accession No. 1541, ASME-CSME Fluids Engrg. Conf.,* Montreal, Quebec, May 13-15, 1974. *Fluidic State-of-the-Art Symp.* **1,** 1974, Harry Diamond Laboratories, Washington, D.C.

422-09637-600-90

ACOUSTICALLY CONTROLLED TURBULENCE AMPLIFIERS

(*b*) National Research Council of Canada.
(*c*) Dr. K. Sridhar.
(*d*) Experimental, theoretical and basic research for M.A.Sc. and Ph.D.
(*e*) Develop a design procedure for shrouded acoustically controlled turbulence amplifiers.
(*h*) **An Investigation of Acoustically Controlled Turbulence Amplifiers,** G. W. Rankin, *M.A.Sc. Thesis,* Univ. of Windsor, 1974.
An Investigation of the Dynamic Response of an Acoustically Controlled Turbulence Amplifier, G. W. Rankin, K. Sridhar, *Paper B-1, Proc. 6th Cranfield Fluidics Conf.,* Cambridge, England, Mar. 1974.
Static Characteristics Shrouded Acoustically Controlled Turbulence Amplifiers, G. W. Rankin, K. Sridhar, *Paper 75 WA/Flcs-9, ASME Winter Ann. Mtg.,* 1975. Also published in *Trans. ASME, J. Fluids Engineering* **98,** pp. 476-482, Sept. 1976.

422-09638-020-00

REYNOLDS STRESSES IN STRAINED FLOWS

(*c*) Dr. H. J. Tucker.
(*d*) Experimental.
(*e*) Determination of Reynolds stresses in a variety of pure strain fields in yielding information which is useful in general calculation procedures for turbulent flows.

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16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

Current and recently concluded research projects in hydraulics and hydrodynamics for the years 1975-1976 are summarized. Projects from more than 200 university, industrial, state and federal government laboratories in the United States and Canada are reported.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

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