DC WRRC Report No. 60

UNIVERSITY
OF THE
DISTRICT OF COLUMBIA

water resources
research center
WASHINGTON, DISTRICT OF COLUMBIA

FY 1983 INSTITUTE FINAL PROGRAM REPORT (WASHINGTON, D.C)

September 1984

FY 1983 INSTITUTE FINAL PROGRAM REPORT (WASHINGTON, D.C.)

Dr. M. H. Watt, Director

"The research on which this report is based was financed in part by the United States Department of the Interior as authorized by the Water Research and Development Act of 1978 (PL 95-467)".

September 1984

University of the

District of Columbia

VAN NESS CAMPUS
4200 CONNECTICUT AVENUE, N.W.,
WASHINGTON, D.C. 20008

D. C. WATER RESOURCES RESEARCH CENTER
(202) 282-7333/4

October 22, 1984

J. Shelley Welch Contracting Officer
U.S. Department of the Interior
Geological Survey
WGS-Mail Stop 205A
Reston, Virginia 22092

Dear Mr. Welch:

Enclosed please find the following:

o FY 83 Institute Final Program Report
- Original and nine copies
- Abstract
- NTIS card

o Technical Completion Reports for the following projects:

"Development of Frequency Functions for Urban Non-Point Risk Evaluation" by G.K. young, Project No. 3709-04

Original and nine copies
Abstract
Synopsis
NTIS card

"Derivation of Unit-Day-Values for Recreation Benefit Valuation in Water Resource Planning Based on Comprehensive Theoretical Framework" by R.C. Waters, Project No. 3709-06

Original and nine copies
Abstract
Synopsis
NTIS card

"Identification and Prioritization of *the* Water Resources Problems and Research Needs in the District of Columbia" by M.H. Watt, Project No. 3709-23

Original and nine copies
Abstract
Synopsis
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"Evaluation of the Impact of Urbanization on the Hydrogeological Conditions of the Fall Line Cities" by M.H. Watt, Project No. 3709-02
Original and *nine* copies
Abstract
Synopsis
NTIS card

o Progress reports for the following projects:

"Development of an Improved Test for the Determination of Biochemical Oxygen Demand" by B.T. DeCicco, Project No. 3709-05 Original and nine copies

"Model of Flow and Non-Point Source Pollution in the Tidal Portion of the Potomac River" by J. Obeysekera, Project No. 3709-07 Original and *nine* copies

"Assessment of the Fact of Non-Point Source Pollutants on an Urban River" by M.H. Watt, Project No. 3709-08
Original and nine copies

Sincerely,

Mamadou H. Watt, Ph.D.
Director

MW/pem Enclosures

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Selected Water Resources Abstracts

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D.C. Water Resources Research Center, Report No. 60, University of the District of Columbia, September 1984.

16. Abstract

This FY 83 Institute Final Program Report presents the completed and continuing projects that the D.C. Water Resources Research Center conducted between August 1, 1983 and September 30, 1984. These projects are: 1) "Evaluation of the Impact of Urbanization on the Hydrogeological Conditions of the Fall-Line Cities" by M.H. Watt, Project No. 3709-02; 2) "Development of Frequency Functions for Urban Non-Point Risk Evaluation" by G.K. Young, Project No. 3709-04; 3) "Derivation of Unit-Day-Values for Recreation Benefit Valuation in Water Resource Planning Based on a Comprehensive Theoretical Framework" by R.C. Waters, Project No. 3709-06; 4) Identification and Prioritization of the Water Resources Problems and Research Needs in the District of Columbia by M.H. Watt, Project No. 3709-23; 5) "Development of an Improved Test for the Determination of Biochemical Oxygen Demand" by B.T. Decicco, Project No. 3709-05; 6) "Model of Flow and Non-Point Source Pollution in the Tidal Portion of the Potomac River" by J. Obeysekera, Project No. 3709-07; and 7) "Assessment of the Impact of Non-Point Source Pollutants on an Urban River" by M.H. Watt, Project No. 3709-08. Also, the activities of the Center included seminars which are described inside the report.

17a. Descriptors

*Groundwater, *Hydrology, *Unit-Day-Values, *Urbanization, *Non-Point Sources, Dewatering, Statistical methods, Water quality, Run-off, Microcomputers, Recreation, Seminars, Mathematical models

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Abstractor M.H. Watt

Institution D.C. Water Resources Research Center

WRSIC 102 (REV. JULY 1983)

FOREWORD

The D.C. Water Resources Research Center has now passed the decade. During its 10 years of operation, the Center has conducted more than 50 projects, organized more than 20 major conferences and seminars and trained about 52 students in the field of water research. A number of these students obtained their Ph.D., Masters, and/or B.S. degrees. The Center's reports were widely-distributed and well received in all the states and in a number of foreign countries. Some of the Center's investigators have gained local recognition, while others have become nationally and internationally known. After a period of uncertainty in 1982 and 1983 and much scrutiny, Congress has recognized the need to continue water research in the United States and voted *overwhelmingly* to continue the program for the *next* 5 years.

The Center is designed to conduct and facilitate the development of innovative water research, transfer the results of the research, inform the public about water resource problems, and train future water resources managers and scientists on an interdisciplinary basis. Faculty researchers from the 6 universities within the District of Columbia and personnel from local agencies have contributed to the Center's program. The cooperating universities are the University of the District of Columbia, Howard University, Georgetown University, The George Washington University, The Catholic University of America, and The American University. The Center works closely with local, state, federal and regional water resource management agencies and other water centers particularly in the northeast region. Basic funding for the D.C. Center and the other 53 centers and institutes located throughout the United States has been provided through the "Enabling Water

Research Act of 1964", later amended as the "Water Research and Development Act of 1978". Funds for the D.C. Center are complemented with matching funds from the University of the District of Columbia and the other cooperating universities.

ABSTRACT

Like any other geographic area, the District of Columbia has rivers, lakes, groundwater, public water supply, and wastewater treatment systems. The variety of uses of water such as domestic and industrial consumption and recreation naturally place heavy burden on the water resources. Research that provides support to the protection and management of the District's water has always been the focus of the D.C. Water Resources Research Center. With knowledge gained through research, the Center assists water resource managers' and the public in their efforts to improve water quality and conserve water resources.

In updating its five year plan for water research, the D.C. Center has conducted a survey and contacted a wide range of individuals, managers, researchers and the community at large. The problems of highest priority in D.C. are as follows:

o The water quality of the Anacostia River is poor

o Combined sewers overflow pollute the receiving waters o Non-point source pollution is degrading surface water

o There are many undesirable effects of urbanization, land use policies and water quality downstream from development

These problems are highlighted in the technology transfer project entitled, "Prioritization of Water Resources Research Goals and Objectives".

During FY 83 the Center has supported 6 projects:

1. "Evaluation of the Impact of Urbanization on the Hydrogeological Conditions of the Fall-line Cities"

2. "Development of Frequency Functions for Urban Non-point Source Risk Evaluation"

3. "Development of an Improved Test for the Determination of Biochemical Oxygen Demand"

4. "Derivation of Unit-Day-Values for Recreation Benefit Valuation in Water Resource Planning, Based on a Comprehensive Theoretical Framework"

5. "Improved Accuracy in Modeling of Non-point Sources Water Quality and Flow in Tidal Portions of the Potomac River Basin"

6. "A Contribution of Non-point source Pollutants to the Hydrology and Quality of the-Tidal Portion of an Urban River"

1983 has been a year of significant water resource events for the District of Columbia. A few examples are: the completion of the Chesapeake Bay Program, the reappearance of blue green algae on the banks of the upper Potomac estuary, the rapid progress of submerged aquatic vegetation, the new water resource bill for the District of Columbia, and the new agreement between the state of Maryland and the District of Columbia for the cleaning up of the Anacostia. The Center's major thrusts were in the non-point source pollution and watershed studies. It found that while the Potomac River has received much attention and has improved noticeably, the Anacostia River and the small D.C. streams on the other hand have been completely neglected and are severely impacted by urbanization, land use and other pollution factors. Projects 2, 5, and 6 above are concerned with these aspects. Projects 3, 5, and 6 have been extended.

Project No. 2 entitled, "Development of Frequency Functions for Urban Non-point Source Risk Evaluation" has developed new methods which allow a rapid and accurate assessment of runoff and water quality features of urban catchments. Because the methods used microcomputers, decision makers will save time and cost in comparison with the high cost of using existing methods on mainframe computers.

4. "Derivation of Unit-Day-Values for Recreation Benefit Valuation in Water Resource Planning, Based on a Comprehensive Theoretical Framework"

5. "Improved Accuracy in Modeling of Non-point Sources Water Quality and Flow in Tidal Portions of the Potomac River Basin"

6. "A Contribution of Non-point Source pollutants to the Hydrology and Quality of the -Tidal Portion of an Urban River"

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Project No. 2 entitled, *"Development* of Frequency Functions for Urban Non-point Source Risk Evaluation" has developed new methods which allow a rapid and accurate *assessment* of runoff and water quality features of *urban catchments.* Because the methods used microcomputers, decision makers will save time and cost in comparison with the high cost of using existing methods on mainframe computers.

For the first time the Center has funded a project dealing with groundwater. Although groundwater is not a source of water supply for the major cities in the eastern U.S., the problems associated with urbanization can no longer go unnoticed. The "Evaluation of the Impact of Urbanization on the Hydrogeological Conditions of the Fall-line Cities" project studies the impact of urbanization on the groundwater and vice versa. The project coupled with information dissemination activities is gaining increased attention among researchers and water resource managers.

Now that the Potomac River as well as many other rivers in the U.S. are being increasingly used for a variety of recreational activities, it is timely to study the benefits associated with the recreational use of the rivers. The project entitled, "Derivation of Unit-Day-Values for Recreation Benefit Valuation in Water Resource Planning, Based on a Comprehensive Theoretical Framework" has indicated that the unit-day-value method is a more realistic approach to a complex problem such as estimation of recreation benefits. It allows political decision makers some latitude in their decision making and also provides the water agencies with a method for implementation which is relatively straight forward and simple.

One of the major focuses of the Center continues to be information dissemination. The highlight of the information dissemination activities was the preparation of a sludge management seminar.

The sludge management problem of the District stems from a combination of factors including limited available options - ocean dumping, incineration, land fill, composting, etc., socio-political and economic factors.

The seminar was organized to create a forum for discussion by managers, technical personnel, and the community on the sludge management issues facing the District of Columbia, and to increase the knowledge of U.D.C. students, faculty and staff on various environmental techniques and opportunities. The participants included students, faculty, the general public, and representatives from the D.C. Department of Public Works, the Beltsville Agricultural Research Center, the National Science Foundation, the Environmental Protection Agency, Interstate Commission on the Potomac River Basin, the Metropolitan Council of 'Governments, and Washington area water resources agencies.

The seminars held during the academic year 1983-84 are as follows:

October 19, 1983	James Burton Special Assistant Water Research Department of the Interior "Microcomputers in Water Research Management"
November 17, 1983	AGRICULTURAL EXPERIMENT STATION PROGRAM AND ACTIVITIES Mohamed Elhelu, Professor University of the District of Columbia "Heavy Metals in Urban Gardens" Victoria Guerrero, Professor University of the District of Columbia "Urban Raccoons and Rabies: Ecological, Epizootiological and Immuniological Assessment" James Preer, Professor University of the District of Columbia "Soil Properties Affecting Sorption of Heavy Metals from Waste (NE-96)" Joshua Kearney and Thedola Milligan, Professors University of the District of Columbia "Quality Maintenance and Control in Marketing and Storage of Vegetables (NE-116)"
April 12, 1984	SLUDGE MANAGEMENT Wallace White and John R. Thomas WSUA, Department of Public Works "D.C. Sludge Management"

April 12, 1984

Lawrence Sikora
USDA, Beltsville

"Land Applications"

Donald A. Jackson
Geraghty & Miller, Inc.

"Groundwater Monitoring and Sanding at Sludge Disposal Sites"

John R. Short
Ecological Services Laboratory
National Park Service

"Composting of Septage and Liquid Wastes Within a National Park"

Edward Bryan
National Science Foundation

"Innovative Concepts in Sludge Management"

James Preer
University of the District of Columbia

"Heavy Metals in Sludge"

Charles Spooner
Environmental Protection Agency

"Existing and Proposed EPA Sludge Management Regulations"

The Sludge Management Seminar was followed by a panel discussion chaired y Austan Librach, Council of Governments and representatives who included: John R. Thomas, Department of Public Works, Rufus Chaney, U.S. Department of Agriculture, David Sobers, Montgomery County, Ed Pison, Prince Georges County, and Charles Spooner, Environmental Protection Agency.

COOPERATIVE ARRANGEMENTS WITH UNIVERSITIES AND STATE AGENCIES

The Center has signed cooperative agreements for research with The Catholic University for two projects entitled, "Development of Frequency Functions for Urban Non-point Source Risk Evaluation" by Dr. G. Kenneth Young, Adjunct Professor, Department of Civil Engineering and "Development of an Improved Test for the Determination of Biochemical Oxygen Demand" by Dr. B. T. DeCicco, Professor, Department of Biology. The second agreement was with The George Washington University for the Projects entitled, "Derivation of Unit-Day-Values for Recreation Benefit Valuation in Water Resource Planning, Based on a Comprehensive Theoretical Framework" byDr. R. C. Waters, Professor, Department of Engineering Administration, and "Improved Accuracy in Modeling of Non-point Source Water Quality and Flow in Tidal Portion of an Urban River" by Dr. J. Obeysekera, Research Scientist, Department of Civil, Mechanical, and Environmental Engineering.The Center has renewed and updated a list of its memberships to its Research Advisory Council and Technical Evaluation Committee (see attached). The members of the Technical Evaluation Committee and the Research Advisory Council are from the District water agencies. Their roles include assisting in the Center's proposal evaluations and report reviews. In turn, the Director of the D.C. Center participates in an advisory capacity in many of the local and regional water resource agencies. The Director is a conIIaissioner of the District of Columbia to the Interstate Commission on the Potomac River Basin, and has testified at the District building for the D.C. City Council on behalf of the D.C. Water Pollution Control Act. He also spoke and lectured at many meetings, namely at the newly created D.C. Soil

and Water Conservation District. The Center invites the community at large and the water agencies to participate in its seminars and conferences. It distributes its reports, brochures and newsletters to an extensive distribution list which includes community members, water resource officials, researchers, students, and other interested persons.

"Evaluation of the Fact of Urbanization on the Fall-Line Cities" and "A Contribution of Non-point Source Pollutants to the Hydrology and Quality of the Tidal Portion of an Urban River" are funded to the University of the District of Columbia. Finally, the Center continues its efforts with the Historically Black Colleges and Universities (HBCU) in the District of Columbia to inform and to obtain more research proposals.

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Assistant Professor Georgetown
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SYNOPSIS

Title: "Groundwater Problems in the Mid Atlantic Fall-Line Cities

Principal Investigators: M.H. Watt and J.V. O' Connor,
University of the District of Columbia

Statement of Purpose: The purpose of this study is to evaluate the interaction between the groundwater and the urbanization in the Fall Line zone of the Mid-Atlantic region. The Fall Zone is a dividing zone between the Piedmont province and the Atlantic Coastal Plain province in the East Coast of the United States. The Fall Zone extends from. New York to Georgia. The cities that lie along the Fall Zone are referred to as Fall-Line cities (e.g., Philadelphia, Wilmington, Baltimore, Washington, and Richmond), specific objectives are: 1) to increase the understanding of the history and the sciences of the local groundwater regime under the cities; 2) to gather information on groundwater changes with urbanization; and 3) to evaluate recent human activities and their impact on the groundwater situation.

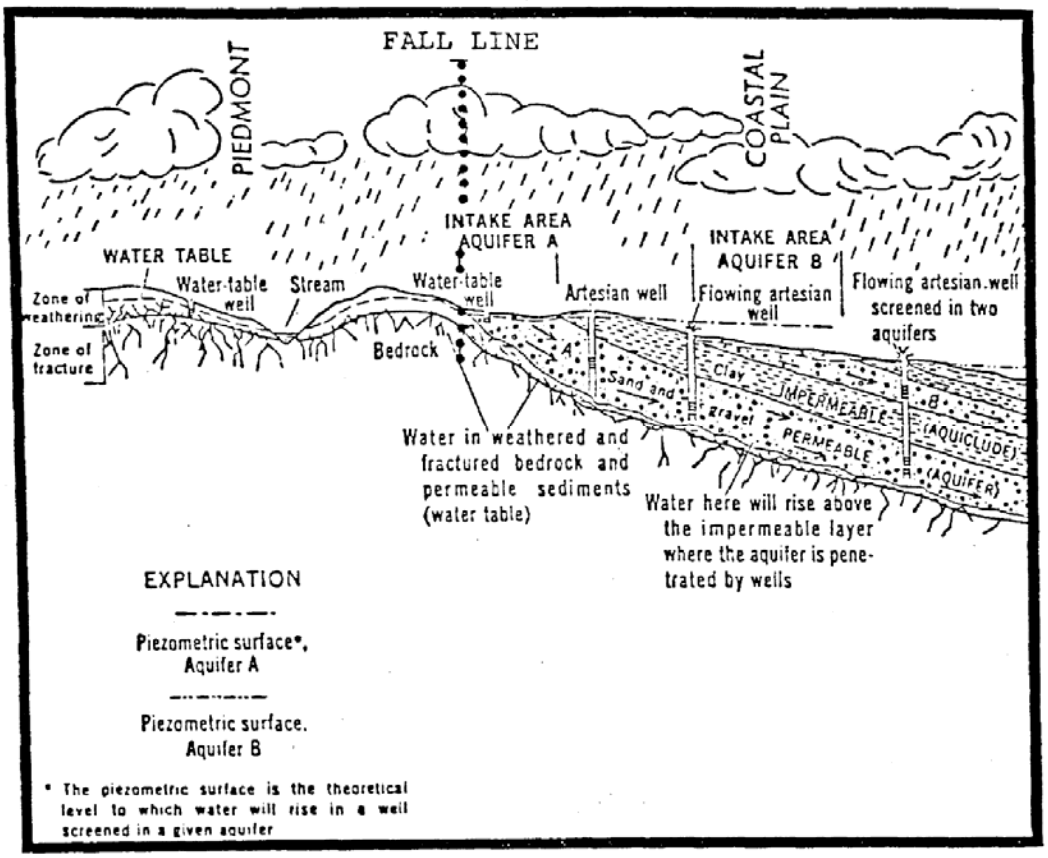
Methods and Procedures: Before the mid 60's urban growth in the Fall-Line cities was limited. However, after the mid 60's, increased urban activities caused some attention to be focused on groundwater in these cities due to quality problems involving contamination. In order to understand the groundwater system in the Fall-Line cities, a comprehensive background study (i.e., review of reports at the local, county, and state levels) was conducted. The salient differences between the Piedmont and Coastal Plain were examined. Once the study area was well defined, data on various *parameters* such as the groundwater table, quantity, tunnel excavation and other related engineering activities were acquired. Because of the dispersed nature of the data, interviews were conducted to obtain additional relevant information.

Principle Findings: The largest quantities of groundwater can be found in the Coastal Plain surface deposits. Under present conditions, these aquifers have a potential yield of several million gallons of water per day. However, pollution from human activities (such as leakage of oil and gasoline) leading to contamination of the groundwater has been recognized as a major problem. Additionally, industrialization and other construction activities have a major impact on the groundwater and vice versa. Groundwater impacts the construction industry through activities such as corrosion, dewatering and add watering. Geological boundaries, perched groundwater table fluctuations, vertical mixing and hydraulic gradient also impact construction.

Conclusion: This project addressed a large area namely the Mid-Atlantic Fall Zone. However, it was limited in scope. The project focused on the Fall-Line cities, specifically on the interaction between urbanization and groundwater. As the cities developed, significant stress was placed on the quantity and quality of the groundwater. In these cities the most obvious impact of urbanization on groundwater is the reduction of recharge areas. Fluctuations of the water table by dewatering, and addwatering, through building construction and tunneling activities, and modification of groundwater flow direction, are a few examples related to the impact of construction on the quantity of groundwater. Qualitatively, groundwater in the Fall Zone is affected by natural and urban activities. Of all the contamination problems, oil and gasoline leaks to the groundwater, and leachates from dump sites and landfills are the most significant. Conversely, groundwater impacts the construction industry through foundation problems, settlement, seepage, and corrosion, etc.

Pollution from natural sources is not very well understood. Consequently there is a need for management to develop an understanding of the occurrence, the flow, and other basic mechanisms of groundwater. In urban areas detailed information on wells, and activities that directly or indirectly affect groundwater should be developed and centralized. Because of the site specificity of groundwater problems, management responsibilities should rest with local and city governments rather than the Federal government. Even though groundwater use is presently limited to the Fall-Line cities, it is necessary to develop management policies that would ensure future protection and wise utilization of this important resource.

Publications: None


FALL LINE
PIEDMONT
COASTAL PLAIN
INTAKE AREA AQUIFER A
INTAKE AREA AQUIFER B
WATER TABLE
Water-table well
Stream
Water-table well
Artesian well
Flowing artesian well
Flowing artesian well screened in two aquifers
Zone of weathering
Zone of fracture
Bedrock
A
Sand and gravel
Clay
IMPERMEABLE
PERMEABLE
B
(AQUICLUDE)
(AQUIFER)
Water in weathered and fractured bedrock and permeable sediments (water table)
Water here will rise above the impermeable layer where the aquifer is penetrated by wells
EXPLANATION
Piezometric surface*, Aquifer A
Piezometric surface, Aquifer B
* The piezometric surface is the theoretical level to which water will rise in a well screened in a given aquifer

Project No. 3709-04

SYNOPSIS

Title: "Development of Frequency Functions for Urban Non-Point Risk Evaluation"

Principle Investigator: G. Kenneth Young
The Catholic University of America

Statement of Purpose: Non-point source pollution is an area of increasing concern to urban environments such as Washington, D.C. Surface waters in such areas are degraded by pollutants, particularly sediment and siltation from surrounding lands. Previous investigations have employed mathematical models to simulate the process of water transport and sediment erosion through which pollutants are introduced into the environment. Such simulations have been shown to yield a high degree of accuracy when calibrated and compared to measurements made from test watersheds. Previous model investigations have been performed in complex, large scale computer simulations, resulting in time consuming and expensive simulation assessments. Urban planners require practical tools to assess the risk of non-point pollution in urban environments; such tools must be easily accessible, convenient to use and cost effective.

The objective of this study is to develop and test a daily time increment small watershed continuous simulation model of non-point source pollution emissions. The model is to incorporate soil moisture accounting, soil loss computations for pervious areas and pollutant accumulation and wash-off computations for impervious areas. The model parameters are to form a small and manageable set. To the extent practical, members of the parameter set will be selected using physical characteristics of the water-shed.. The remaining small subset will be calibration parameters. The intended use of the model is to study the convolution of rainfall distributions. The derived distributions are to be determined using time series simulations.

Methods and Procedures: The approach of this investigation entails the adaptation and simplification of existing rainfall, run-off, soil moisture and sedimentation models in a microprocessor based simulation.

The variables and logic of previously developed complex models of the physical processes will be analyzed by examining sensitivity results.

Those variables and model assumptions that have little to no bearing on results will be eliminated. Simplifications will be sought that are conceptually correct and which capture as much of the output response as possible. These simplifications will be integrated into mathematical models that will fit on microcomputers and that generate output time series quickly. The simplified model will be checked against field data, calibrated and verified.

Principle Findings:

1. A daily accounting model of urban run-off and pollutant concentrations was developed as a tool for urban water planning and analysis.

2. The model is feasible on a microcomputer.

3. The model has the following parameters:

Maximum Infiltration
Percolation
Root Zone Depth
Porosity
Slope
Soil Loss Coefficient
Active Layer Thickness
Washoff Coefficient
Heavy Rain Infiltration Intercept
Heavy Rain Infiltration Slope
Partition Coefficient
Pollutant Dissipation Coefficient
Monthly Evapotranspiration

4. Sensitivity analysis indicates the following ranking of most sensitive parameter:

   highly sorbed pollutants

   Soil loss coefficient
   Active layer thickness

   highly soluble pollutants

   Dissipation coefficient
   Washoff coefficient

5. Impervious area rational design methods and pervious area soil moisture accounting methods can be integrated into one accurate and simple model system.

6. The model can be used to generate emission frequency function for small urban watershed for differed rainfall inputs and cultured factors.

Conclusion: It is expected that these results will be used by city, state, and Federal urban water planning and use components. These new methods allow a rapid and accurate assessment of run-off and water quality features of urban catchments. Time and cost savings result from use of the new microcomputer-based methods. These savings are in comparison to the high cost of using existing methods on mainframe computers.

Publications: No publications are associated with the content of this report.

Project No. 3709-06

SYNOPSIS

Title: "Derivation of Unit-Day-Values for Recreation Benefit Valuation in Water Resource Planning Based on a Comprehensive Theoretical Framework"

Principal Investigator: Robert C. Waters
The George Washington University

Statement of Purpose: Normally access to the federal water based recreation opportunities are provided without charge to the user. Over one-half of the annual recreationists at federal facilities visit Corps of Engineers resevoirs.

Since the recreationist does not pay directly for the service received, the issue becomes: how much recreation access should be provided by the ederal government for private consumption? Based on the Flood Control Actof 1936, the agencies have assumed that as long as benefits exceed costs than additional *increments* of recreation opportunities should be provided to the extent that Congress authorizes and appropriates the funds. Although there is some controversy associated with assessing costs, the major issue of contention has been with assessing benefits.

This study evaluates the arguments associated with the willingness-to pay methods (travel cost and contigent approach. Furthermore, it weights the valuation) and the unit-day-value arguments and suggests a course for future action.

Methods and Procedures: This involves the following steps:

a. Evaluation of the current unit day value system.
b. Close cooperation with federal agencies and recreation planners to establish a set of user requirements with respect to the improved unit day value system.
c. Evaluate the possibilities of assessing external benefits and costs arising from water based recreation.

d. Development of a preliminary and dynamic set of unit day values.
e. Get user feedback on the preliminary set of unit day values.
f. Development of a definitive set of unit day values.

Principle Findings: The evidence suggests that federally provided water based recreation is in reality a political process, furthermore the present recommended procedures even if correctly inmplemented do not lead to Parato optimal economic efficiency. The presently recommended procedures are faulty from both a theoretical and an operational basis. From a theoretical point-of-view, they would attempt to maximize national economic development, but in the process they would increase the maldistribution of income. From an operational point-of-view, the procedures are frought with undefined uncertainties and ignore conditions which lead to suspect and variable results.

When evaluate with the flaws in the TCM and contingent valuation methods and the costs to gather and analyze the required data, the UDVM's appeal becomes greater since it also has the ability to consider aesthetic values and regional economic benefits.

Conclusion: In conclusion, one is not dealing in an area where national economic efficiency is truly being sought. In each water based recreation project there are political considerations which carry greater weight than market efficiency. These factors should be taken into account. The UDVM allows-political decision makers latitude in their decision making, and allows the agencies a method for implementation which is relatively straight forward and simple. As for the economists favoring the WTP for its theoretical appeal, as indicated above, water based recreation and recreation as a whole go beyond economic efficiency into the political-social realm

The Water Resources Council has asserted that as there is "No way to verify estimated benefits by measuring 'actual' benefits the arguments will remain just that, academic". There is no reason not to look at the UDVM for setting values for recreational benefits. The UDVM is a more realistic approach to a complex problem which goes beyond economic efficiency. A valuation board of the Congress should be established to set appropriate values or guidelines for water based recreation. Until then leaving the valuation issue to each agency seems appropriately expedient.

Publications: None

Title: Identification and Prioritization of the Water Resources Problems and Research Needs in the District of Columbia

Mamadou H. Watt Sheila A. Besse
DC WRRC

Statement of Purpose: When there are a multitude of water resources issues and funds are limited, it is essential to base decisions on essential priorities. The purpose of this investigation is to identity and prioritize the District of Columbia's water resources problems. Results from this study will be used by the DC WRRC to establish research goals and objectives and to formulate a research program plan that will contribute to the solution of these problems.

Methods and Procedures: The procedures of this study may be summarized

1. Select a methodology to identify and rank water resources problems and research needs;

2. identify present water resources problems in the District of Columbia;

3. prioritize identified water resources problems from the viewpoint of the water researcher, planner, manager, and policy maker;

4. select those water resources issues that are perceived as critical or of high priority and which further research would contribute to their solution; and

5. define research goals and objectives that will address identified local water issues.

A uni-objective approach using a questionnaire format was selected to prioritize the water resources problems. This format was selected because it provided an effective way to contact as many people as possible within a short time and insured that those individuals concerned about the District's water issues were reached. Problem statements included in the questionnaire were gathered from a variety of sources including governmental technical reports, water related legislation, news items, opinions of experts in the field, and water resources problems identified by the Center four years ago.

Principal Findings: The water quality of the Anacostia River as well as D.C.'s combined sewer overflow problem lead the list of ranked issues. In addition, the impact of non-point source pollution on D.C.'s rivers and streams and the effects of present land-use policies on water quality received high ranking. Planning strategies for the removal of unauthorized discharges into District waters also appeared to be a major concern to respondents. And of interest were the results that both acid rain and groundwater which are high priority issues in the northeast region of the U.S. did not appear to be of such high concern to the respondents.

Conclusions: This report highlights the findings of a survey conducted by the DC WRRC to identify and prioritize the District of Columbia's water resources issues. The most important problems were found to be the Anacostia River's water quality, non-point source pollution, and combined sewer overflows. In addition, the survey found that many respondents did not necessarily perceive as critical or urgent those problems that have received considerable media attention. The Hydrilla problem is one such example.

A study of this type shows that, despite its limited scope, simple and straight forward survey techniques can be used to identify problems and rank them in a manner that closely represents the reality. In the case of the District of Columbia, a major emphasis of managers, planners, and researchers is the Anacostia River.

DEVELOPMENT OF AN IMPROVED TEST FOR THE DETERMINATION OF BIOCHEMICAL OXYGEN DEMAND

(Progress Report)

Principal Investigator: Dr. Benedict T. DeCicco Project No. 3709-05

The research in progress at Catholic University seeks to develop a modified B.O.D. test which will offer the following advantages over the present method:

l. reduce the time from 5 to 2 or 3 days;

2. improve the precision by replacement of inconsistent "natural" -seed inoculation with a standardized, reproducible "artificial" seed consisting of selected highly active microorganisms;

3. reduce B.O.D. seed correction by maintaining a stable seed mixture in a low nutritive medium; and

4. make available a standardized, stable, artificial seed which can be maintained for long periods in an active form by persons with little training in microbiology.

The development of a standard "artificial" seed is the outgrowth of related studies on the nutritional versatility of diverse bacteria which is a primary interest of the Microbial Applications Laboratory directed by B.T. DeCicco at Catholic University. Our laboratory has tested about 50 bacterial strains for their nutritional versatility and their long term survival under sparse nutrient conditions. From these we have selected the most promising strains for this study. Some of these are standard American Type Culture Collection (ATCC) strains, while others are strains collected from clinical laboratories, contaminated pharmaceutical products or from water samples.

The list of the initially selected strains is shown in Table 1. These organisms all are nutritionally diverse, utilizing many different organic compounds, are common in nature and, with one exception, are considered non-pathogenic. All of these organisms were shown to be able to survive for months in a medium consisting of only tap water plus sodium thiosulfate (as a dechlorinator). The list consists mainly of Gram negative nonfermentative bacteria, although a few fermentative species (Enterobacter aerognes and E. gergoviae) were included.

The selection process began by adding all of the strains except the last one shown in Table 1 to separate autoclaved samples of sewage influent from Blue Plains. The growth of each organism was followed for five days at 30^0C. The results are shown in Figure 1. For comparison an untreated (unautoclaved) sample of the same sewage influent was incubated with the inoculated samples to show the cell population with a natural seed.

The results show most of the pure cultures, as well as the natural population, reaching their maximum cell yields within 1-2 days. Most strains reached their peak numbers on the second day and remained relatively stable after this. The peak cell numbers for all strains except E. aerogenes were between 2×10^6 and 5×10^8 organisms/ml and were in the same range as the natural population.

Five of the six strains showing the best growth were selected for further study. The sixth strain, P. aerucrinosa, was eliminated at this point because it is a potentially serious pathogen and we felt it would not be suitable for handling by persons inexperienced in microbiology, as some of the potential users of our procedure may be. The five strains were then inoculated together into sterile sewage influent in order to assess their

ability to survive and grow in mixed culture. This would demonstrate positive and negative effects that may result from competition. Mixed sewage cultures were incubated at both room temperature (24º C) and 30º C. The five strains were tested and their cell yield at the two temperatures are shown in Table 2. The two organisms yielding the best growth were P. putida and Acinetobacter. P. cepacia and Achromobacter were not recovered (NR) at dilutions of 10^{-3}. Since P. cepacia is a very versatile organism nutritionally, rather than eliminate this species a second strain from our collection was used. This new strain is the last one listed in Table 1 and will be referred to as P. cepacia #4.

The experiment shown in Table 2 was repeated using P. putida, Acinetobacter, E. gergoviae and P. cepacia #4. The mixture of organisms was run at 20^0, 30^0 and 35^0C. The results are shown in Figure 2. Again, P. putida and Acinetobacter grew best, with P. cepacia lagging behind and E. gergoviae not being recovered at any of the three temperatures.

It is interesting to note that both species of Enterobacter did poorly in our studies with wastewaters. These species were included because several previous studies on the B.O.D. test used Enterobacter as their prime organisms. Our earlier studies showing that the Enterbacteriacae are not as versatile as the nonfermentative organisms were confirrred by these results. Based on these data, the organisms selected for initial studies with an artificial seed were P. putida, Acinetobacter, P. cepacia and P. fluorescens.

The amount of seed material added to the diluted sewage sample for B.O.D. determination is critical. When settled sewage is added as a natural seed, significant amounts of organic matter are introduced with the seed organisms, adding to the B.O.D. and requiring that corrections be made. As higher amounts

of seed are added the corrections became very high. The net result is that relatively low concentrations of natural seed organisms are used in order to keep the corrections within acceptable limits. However, the low concentrations of seed organisms slow the rate of organic consumption, leading to the long period (5 days) which the B.O.D. test usually requires.

By using an artificial seed of the type studied here, the seed organism can be grown to high levels in low nutrient media, and in the process consume almost all of the useable nutrient. This means that in theory the artificial seed could contain higher microbial populations, leading to a more rapid B.O.D. test, without requiring large seed corrections. This was tested by adding different amounts of artificial seed material to the dilution water used for B.O.D. determinations to yield dilutions of 1:10, 1:100 and 1:1000. The four organisms mentioned above when added at these dilutions gave cell concentrations of 1.7×10^6 orgs/ml, 1.7×10^5 orgs/ml and 1.7×10^4 orgs/ml respectively. When B.O.D. determinations were performed on a primary influent sewage sample using these three seed concentrations, the results seen in Table 3 were obtained. Thus it can be seen that the artificial see yielded results at 1:100 and 1:1000 dilutions which were similar to results with the natural seed at a 1:1000 dilution. This means that the artificial seed can be used at a 1:100 dilution without influencing the B.O.D. but at a cell concentration that should shorten the time required for the B.O.D. test.

TABLE 1.

SELECTED ORGANISMS FOR STARTING POOL

Pseudomonas putida *47

Pseudomonas fluorescens ATCC *13525

Pseudomonas cepacia ATCC*25416 .

Pseudomonas aeruginosa ATCC*9027

Achromobacter sp. *16A

Acinetobacter sp.

Enterobacter aerogenes ATCC *13048

Enterobacter gergoviae *8172

Alcaligenes faecalis *fec 3

Pseudomonas cepacia WR clin. iso. *4

Legend for Figure l:

Influent samples were obtained from Blue Plains wastewater treatment plant and kept refrigerated until use.

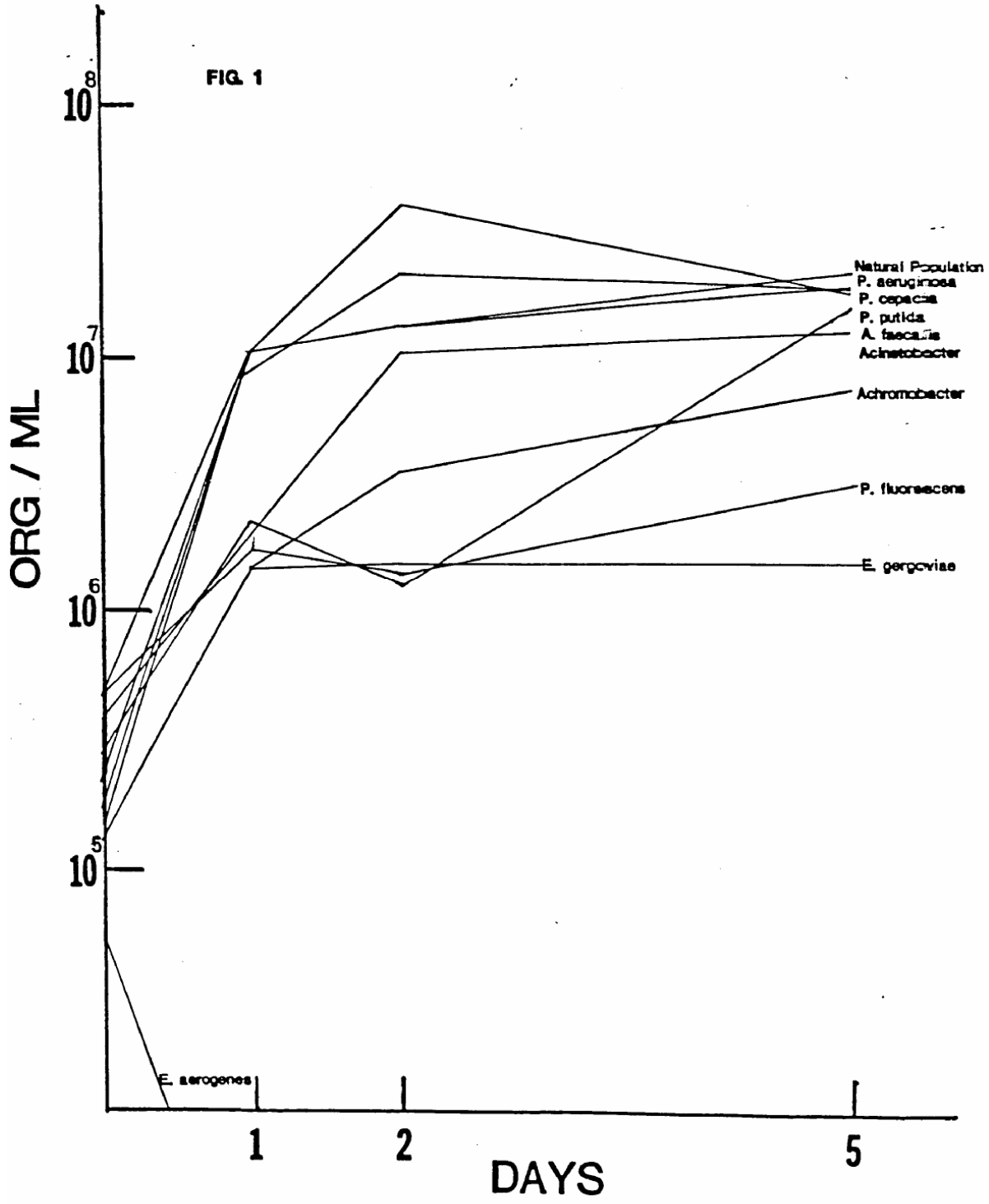


FIG. 1
ORG / ML
10^8
10^7
10^6
10^5
Natural Population
P. aeruginosa
P. cepacia
P. putida
A. faecalis
Acinetobacter
Achromobacter
P. fluorescens
E. gergoviae
E. aerogenes
1
2
5
DAYS

Table 2. Growth of mixed cultures in sterile influent at two different temperatures[a].

ORGANISM	ROOM TEMP.[b]	30°C
P. putida	1.9×10^6	5.3×10^6
Acinetobacter	9.0×10^5	1.6×10^6
A. faecalis	1.0×10^5	5.6×10^5
P. cepacia	NR	NR
Achromobacter	NR	NR

[a] Sewage was obtained from the Blue Plains treatment facility in Washington, D.C. The sewage (secondary influent) was autoclaved the same day of collection and used one day later. Plate counts were done after five days.

[b] Room temperature is taken as 24°C.

Fig. 2 Growth of mixed cultures at three temperatures.

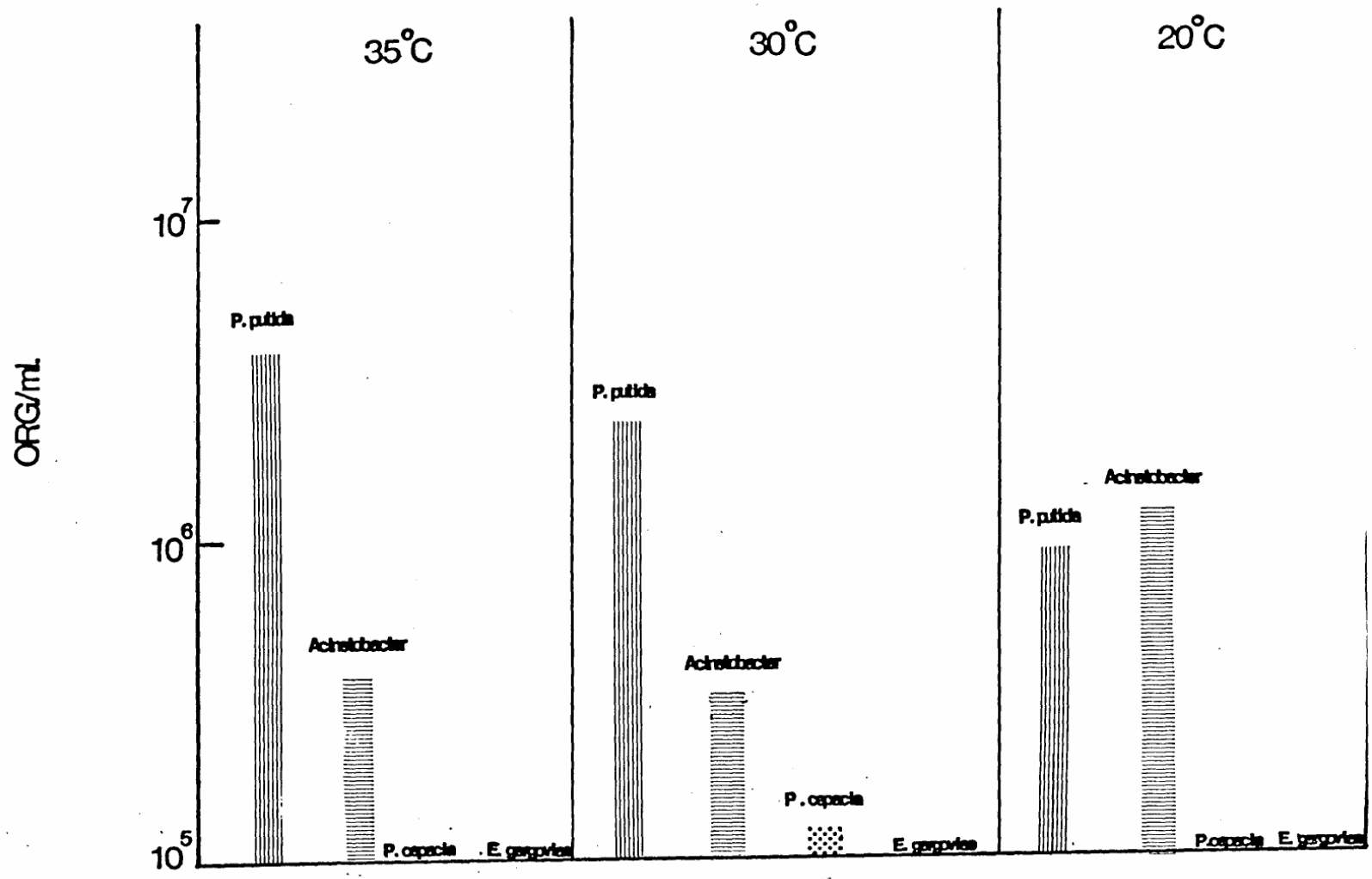


Table 3. Determination of artificial stock seed dilution ratio.[a]

	Ratio of seed material to dilution water using BOD_5		
	1 : 10	1 : 100	1 : 1000
Artificial	111[b]	143	130.8
Natural	ND[c]	ND	138

[a]Natural seed material was from a one day old settled sewage sample (waste liquor) and water sample was from a degritted primary influent.

[b]BOD is read in ppm.

[c]Dilution water was only seeded with the natural seed at the 1:1000 ratio.

MODEL OF FLOW AND NON-POINT SOURCE POLLUTION IN THE TIDAL PORTION OF THE POTOMAC RIVER

(Progress Report)

Principal Investigator: Dr. Jayantha Obeysekera Project No. 3709-07

Six tasks were identified in the original project proposal, submitted in FY 1983:

a. Research data assembly
b. Testing homogeniety of data
c. Normalization of data
d. Analysis and removal of seasonality
   Removal of serial dependence
e. Multivariate correlation analysis

The extent of the completion of the above tasks and the proposed continuations are described below.

Research Data Assembly

Considerable length of time was spent assembling the data, with relatively moderate success. The following agencies were contacted for data collection:

a. United States Geological Survey, both National Center and Maryland distract office.
b. Interstate Commission for the Potomac River Basin (ICPRB)
c. Council of Governments (COG)
d. Department of Environmental Services, Washington, D.C.
e. Washington, Aqueduct Division, U.S. Army Corps of Engineers.
f. U.S. Environmental Protection Agency. STORET
g. Northern Virginia Planning District Commission.

The data collected by various agencies differs significantly in quality, frequency of observation, length and period of records, variables observed, and units reported. Within certain data sets, observations are not uniform temporally making the application of time series models difficult. Based on data that have been received so far, three data sets have been prepared for investigations:

1. USGS--Chain Bridge data set, Oct. 1977-Sept. 1981, approximately 600 observations of discharge, nutrients, sediment, etc.
2. WAD Washington Aqueduct Division data set (intake at Little Falls), May 1963-Feb. 1984, daily for turbidity, alkalinity, hardness, CO_2, pH, etc.; biweekly for DO, BOD, NO_2, NO_3, with missing gaps.
3. DES-Department of Environmental Services data set collected downstream of Chain Bridge, June 1966-Dec. 1983; weekly with many gaps in observations.

The other data being collected and processed includes:

a. STORET (EPA).data since 1966

b. Precipitation data at two or three key stations in the Potomac River basin.
c. Water quality variables observed at Chain Bridge for the period 1973-1984 (from USGS, Maryland Office).
d. gaily temperature, dissolved oxygen, conductivity and pH, at CB for the period 1978-1981 (USGS-Maryland Office).
e. Daily temperature and conductivity at Great Falls for the period 1973-1978 (USGS-Maryland Office).
f. Daily sediment, flow, and some water quality data at Point of Rocks, and Rice Ford upstream of CB for the period of 1961-1983 (USGS Maryland Office).

Testing of Homogeniety of Data

Since data sets are short and nonuniform with respect to observation intervals, it was felt that the nonparametric methods are best to be used for testing homogeniety. Specifically, the recent trend analysis methods described by Hirsh et al. (1982), and Belle and Hughes, (1984) have been employed. The computer programs necessary for these methods have been developed and tested on the USGS data. However, since this data set is short (4 years), its results alone could not definaitely indicate any firm trend in water quality variables.

The WAD and DES data sets are being analyzed at present.

Analysis and Removal of Seasonality

The basic statistical parameters of mean, standard deviation, etc. have been computed for each season (assumed to be a month) for the USGS data set. Although data were pooled into months, sufficient observation were available

for computations of the above.statistics seasonally. Results from the USGS data set indicate a significant seasonal variation of the above statistics of water quality variables. Such results question the validity of past correlation analyses *on* the entire data by ignoring the seasonality in water quality concentrations. The fitting of seasonal variation of statistics by Fourier periodic functions and the application of seasonal analyses to WAD and DES data sets are being carried out at present.

Transfer of Information via Correlation

A special study *on* correlation of water quality variables has been completed by a senior level undergraduate student at George Washington University. The correlation analysis has been carried out on the USGS data set. Since a seasonal variation of the statistical parameters of certain water quality variables was detected, it was necessary to carry out correlation and regression analysis for each season (assumed to be months). This contrasts the previous studies in which the entire data set has been used for correlation without any regard to seasonal variation. In order to determine which variables can be subject try transfer of information correlation matrices were developed for the entire set of water quality variables. It is found that monthly correlation coefficients between concentration of constituents and discharge (or concentration) can range from low values to very high values (above 0.9). This explains partially why previous correlation studies utilizing the entire data set did not show significantly high correlations, due to the averaging effect. In addition to determining the effect of seasonality further, it is necessary to investigate the varying correlations from month to month for any physical explanation. Another interesting finding is for Ammonia whose correlation with discharge takes moderately high negative

values in winter months where as during summer and fall it is positive. It appears to follow the temperature cycle. *The* explanation to these findings needs further investigations. Based on the correlation coefficients, the monthly regression relationships between the constituent concentrations and discharge have been developed for selected water quality variables. At present the extension of the correlation analysis to employ multiple regressions (by incorporating additional explanatory variables such as antecedent runoff) is underway.

ASSESSMENT OF THE IMPACT OF NON-POINT SOURCE POLLUTANTS ON AN URBAN RIVER

(Progress Report)

Principal Investigator: Dr. M. H. Watt Project No. 3709-08

INTRODUCTION

This progress report represents a brief summary of hydrologic and water quality studies of an urban river. The case considered here is the Anacostia River. Increased concern about pollution of the District's waters (particularly he Anacostia River) as evidenced in a public hearing on the 7th of May 1984 regarding the District of Columbia's newly proposed Water Pollution Control Act of 1984 indicated that one of the major problems that should be addressed is on-point source pollution.

A number of tasks were undertaken in connection with this study. A detailed literature review of all past and present studies on the Anacostia River including interviews with water related agencies within and outside the Washington, D.C. area was conducted. Various land use (D.C. proposed generalized land use map 1983-2000), topographic (7.5 minute series) and soils maps including the most current satellite image map - 1 : 100,000 (NASA Landsat) have been analyzed to assist in a more detailed delineation of the watershed's land use and other activities. Extensive water quality and stream flow data (spanning over 15 years) have been analyzed for water quality trends including current on going sampling activities. Additionally a number of computer models and their applicability to an urban stream (including estuarine/tidal conditions) have been reviewed.

OBSERVATIONS

General land use in the Anacostia River basin falls into the following categories: cultivated land represents about 8.2 percent of the total land use while pasture represents approximately 15°s, woodland - 29.4%, urban - 44%, construction and sand and gravel mines - 3.4°d and water bodies - 0.1%.

Analysis of observed data indicates that the water quality of the Anacostia is fair to poor indicating little or no progress in its quality. These water quality problems stem from both point and non-point sources of pollution. The point sources can be attributed to the discharges from combined sewer overflows and perhaps some yet unidentified point source discharges.

While the free flowing portions of the Anacostia tend to transport pollutants very quickly downstream, the estuarine portions are slow, consequently tidal cycles in these areas tend to cause dispersion of pollutant loads delivered to them. The slow tidal currents also create areas for deposition of debris, nutrients, sediments and organic matter transported by the main stem following storm events. It is therefore important to give a high consideration to the estuarine areas when studying the water quality problems of the river especially with regard to algal blooms, high temperatures and sedimentation. The dominant factor in the free flowing upper portions in terms of pollution are generally non-point sources which result from activities such as mining, agricultural practices, suburban developments, park systems, urban storm runoffs, etc. Efforts to improve water quality must recognize the fact that the non-point sources tend to contribute a higher percentage of the total pollution load for most of the parameters. For instance over fifty percent of the sediment contribution from upstream results from mining and construction activities. Specific problem areas include the Upper Northwest Branch and Paint Branch where failing septic tanks result in high bacteria levels. In the main stem, (which also includes tidal portions) nutrients, bacteria and sediment arise from urban storm; water runoff, sewer overflows, excavation and construction activities.

It was observed that sediment, BOD, and nitrification processes created an increase in the oxygen demand resulting in numerous violations of the dissolved oxygen (D.O.) standard of 4.0 mg/1. For instance, out of a total 128 D.O. values,

56 of these were in violation of the water quality standards for the waters of the District of Columbia (with D.O. values as low as 1.5 mg/l being a common occurrence along certain portions of the river).

Other observations indicated that alkalinity values in the river continued to increase occasionally downstream (48 mg/l to 100 mg/1). Alkalinity in the river increases enrichment of the nutrients and greatly affects the growth potential of algae and other aquatic plants. Correlations have been run to confirm the relationships between alkalinity and pH levels. Similarly pH values demonstrated a gradual increase in the downstream direction. Values ranged from 6.0 to about 8.1. A majority of the pH values on the Anacostia are acidic (generally below 7).

Temperature 3n the river showed variability according to seasonal changes. Analysis of river samples also showed a high degree of variability in conductivity. Values ranged from an average of 227 micromhs (June) to about 311 micromhs (July) .However, no reliable chemical and fecal coliform data were available because of contract laboratory failure to meet quality assurance. Similarly, not much work regarding sediment oxygen demand has been done on the Anacostia. The importance of research into these areas cannot be overlooked in evaluating the water quality of the District of Columbia's waters.

FUTURE ACTIVITIES

In order try do a detailed assessment of the non-point source on the Anacostia River, various computer models will be used to simulate present and projected conditions of the watershed in view of the complex land use and ever changing regime of the river. Based on land use and soils maps Nutrient and sediment loading factors can be calculated using the COG's desktop non-point pollution

planning model. Other models reviewed, such as the Dynamic Estuary Model, the EPA's Hydrological Simulation Program - Fortran, the Alternative Model for Urban Water Quality, U.S. Army Corps of Engineers HEC programs, and the Watershed Erosion and Sediment Transport Models would be applied to the most appropriate portions of the watershed. In the application of the models, calibration and verification procedures would necessitate additional sampling and gathering of any other data (hydrologic, etc.) needed for smooth running of the models.

Further determinations would be done on the pH level and pH shifts in the Anacostia River in order to assess the impacts of the pH on other water quality parameters. The study will also focus on the state of the dissolved oxygen, turbidity and overall water quality.

These models developed over the past few decades have gained wide acceptance for watershed systems simulation studies. The models take into account both structural and nonstructural solutions for improving water quality based on relationships between land use and water quality controls which will lead to adequate management decisions.