Georgia Water Resources Institute

Annual Technical Report

FY 1998

Introduction

Research Program

In Fiscal Year 1998, the Georgia Water Resources Institute (GWRI) was involved in a wide range of activities. This report summarizes research, education, technology transfer, and information dissemination activities supported through the WRRI Competitive Grant Program, WRRI Base Grant, as well as funds provided to GWRI by the State of Georgia. In Fiscal Year 1998, the following projects were conducted through GWRI: - Improvement of Water Resources Management Due to Climate Forecasts; - Information System for Water Resources Monitoring and Planning in the Lake Victoria Region; - A Decision Support System for the Western Sterea Hellas Water Resources System; - Water Resources Sector National Assessment of the Potential Consequences of Climate Variability and Change for the United States; - Sustainability of Surficial Aquifer Resources on Endmember (Developed and Pristine) Barrier Islands near Brunswick, Georgia; - A Decision Support System for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in the Southeastern US; - Establishment of Satellite Data Aquisition Facility at the GWRI office.

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Improvement to Water Resources Management Due to Climate Forecasts
Project Number	B-20-640
Start Date	08/01/1997
End Date	06/30/1999
Research Category	Climate and Hydrologic Processes
Focus Category #1	Climatological Processes
Focus Category #2	Hydrology
Focus Category #3	Management and Planning
Lead Institution	Georgia Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Aris P. Georgakakos	Professor	Georgia Institute of Technology	01

Problem and Research Objectives

This project aims at demonstrating the value of climate and hydrologic forecasts on the operation of multi-purpose reservoirs in the US.

Methodology

Information provided by Global Circulation Models (GCMs) relative to precipitation and temperature have been down-scaled to reservoir catchment scale, and have served as input into distributed hydrologic watershed models to estimate reservoir inflow ensembles (consisting of both surface and subsurface flows). Decision systems for selected reservoirs have been developed, which have been run using the generated inflow ensembles to assess the utility of GCM and hydrologic forecasts in reservoir operation.

Principal Findings and Significance

In the reporting period the above described methodology has been applied to Lake Lanier (Georgia). This resulted in an operational decision support system for Lake Lanier, and a set of baseline and projected inflow data. Subsequent analysis of extensive model runs led to an assessment of benefits associated with climatological flow forecasts.

Descriptors

Climate Forecasts Decision Support System Hydrologic Modeling Reservoir Operation

Articles in Refereed Scientific Journals

Forthcoming

Book Chapters

Dissertations

Water Resources Research Institute Reports

Forthcoming

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Information System for Water Resources Monitoring and Planning in the Lake Victoria Region
Project Number	B20-612
Start Date	09/01/1997
End Date	07/31/1999
Research Category	Climate and Hydrologic Processes
Focus Category #1	Management and Planning
Focus Category #2	Hydrology
Focus Category #3	Water Quantity
Lead Institution	Georgia Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Aris P. Georgakakos	Professor	Georgia Institute of Technology	01

Problem and Research Objectives

The objective of this project is to develop a decision support system (DSS) to explore various water resources planning and management scenarios in the Lake Victoria Basin. Participating countries are Kenya, Tanzania, and Uganda. The Lake Victoria DSS is intended to provide the lake stakeholders with the understanding necessary to develop shared-vision water resources management strategies to be ratified by political and legal processes and to be implemented within a cooperative management framework.

Methodology

The DSS integrates conventional and remotely-sensed (satellite) data, geographic information systems, various models (for rainfall estimation, rainfall-runoff, agricultural planning, hydropower scheduling, and lake regulation), computer technology, and meaningful user-model interfaces. These elements are interlinked in a consistent fashion to assess the implications of alternative development actions such as the potential benefits of irrigated agricultural developments, the associated hydropower tradeoffs, and the effects of various lake regulation strategies.

Principal Findings and Significance

In the reporting period all submodels have been developed, including: - Sacramento based distributed hydrologic models for all sub basins in the Lake Victoria watershed; - Operation model for the Owen Falls hydro power facility; - Satellite based rainfall estimation model; - Agricultural planning model based on DSSAT and CROPWAT; - Lake level regulation model. The above elements have been integrated into a comprehensive and operational Windows-based Lake Victoria Decision Support System. A series of one-week workshop (each in Uganda, Tanzania, and Kenya) has been conducted to provide hands-on training to water resources engineers in the three countries in use and operation of the Lake Victoria DSS. Furthermore, in the framework of this project, a water resources engineer from each of the countries Kenya, Tanzania, and Uganda, has been visiting the office of the Georgia Water Resources Institute at Georgia Tech for a period of three months to participate in the development of the system and receive training in its use.

Descriptors

Decision Support System Water Quantity Remote Sensing Geografic Information System Agricultural Planning Hydro Power

Articles in Refereed Scientific Journals

Forthcoming

Book Chapters

Dissertations

Forthcoming

Water Resources Research Institute Reports

Georgakakos A.P., Yao H., Brumbelow K., Bourne S., De Marchi C., Mullusky M. "Lake Victoria Decision Support System", Technical Report No. GWRI/GIT-98-1, Georgia Water Resources Institute and School of Civil and Environmental Engineering, Georgia Tech, Atlanta, May 1998, 102 p. Georgakakos A.P., Yao H., Brumbelow K., Bourne S., De Marchi C., Mullusky M. "Lake Victoria Decision Support System, User Manual, Version 1.0", Technical Report No. GWRI/GIT-98-2, Georgia Water Resources Institute and School of Civil and Environmental Engineering, Georgia Tech, Atlanta, May 1998, 27 p.

Conference Proceedings

Proceedings of the Second Regional Workshop of the FAO Lake Victoria Water Resources Project, Kisumu, Kenya, May 1998 Georgakakos A.P., "A Decision Support System for the Lake Victoria", 12 p.

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	A Decision Support System for the Western Sterea Hellas Water Resources System
Project Number	
Start Date	01/01/1998
End Date	12/31/1998
Research Category	Climate and Hydrologic Processes
Focus Category #1	Hydrology
Focus Category #2	Management and Planning
Focus Category #3	Water Quantity
Lead Institution	Georgia Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Aris P. Georgakakos	Professor	Georgia Institute of Technology	01

Problem and Research Objectives

The objective of this project is to assess the implications and consequences of an interbasin transfer from the Acheloos river basin to the Thessalia valley in central Greece.

Methodology

The methodology used consists of developing a comprehensive decision support system for the Western Sterea Hellas water resources system. The DSS comprises of an optimization and a control-simulation component. The purpose of the former is to develop optimal system operation policies, while the latter serves to evaluate the performance of these policies over the historically (and partly synthetically generated) flow record. These results are used to assess the consequences of the proposed water diversion.

Principal Findings and Significance

In the reporting period an operational Decision Support System (DSS) for the Western Sterea Hellas has been completed. This system represented all reservoirs and hydropower facilities in a detailed fashion, incorporated their operational modes and water use requirements, and developed feedback policies that optimized the system in a fully uncertain framework. The DSS was incorporated into a Windows-based software package: "Western Sterea Hellas DSS 1.0", Software Package, December 1998, Georgakakos A.P., Yao H. The DSS was used to make a comperhensive assessment of the

implications of the proposed water divertion.

Descriptors

Decision Support System Hydrologic Modeling Water Quantity Reservoir Operation Interbasin Transfer

Articles in Refereed Scientific Journals

Forthcoming

Book Chapters

Dissertations

Water Resources Research Institute Reports

Georgakakos A.P., H. Yao, DeMarchi C., Mullusky M., "A Decision Support System for the Western Sterea Hellas Water Resources System", Technical Report, December 1998. Georgakakos A.P., H. Yao, "Western Sterea Hellas DSS 1.0 User Manual", Technical Report, December 1998.

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Water Resources Sector National Assessment of the Potential Consequences of Climate Variability and Change for the United States
Project Number	B-02-631
Start Date	07/01/1998
End Date	12/31/1999
Research Category	Climate and Hydrologic Processes
Focus Category #1	Hydrology
Focus Category #2	Climatological Processes
Focus Category #3	Management and Planning
Lead Institution	Georgia Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Aris P. Georgakakos	Professor	Georgia Institute of Technology	01

Problem and Research Objectives

Climate variability and change pose both challenges and opportunities for the US. To be better prepared, the United States has developed a national assessment process to identify and analyze the potential consequences of climate variability and change. The "Global Change Research Act of 1990" (P.L. 101-606) states that the Federal government: "shall prepare and submit to the President and the Congress an assessment which: (a) integrates, evaluates, and interprets the findings of the Program and discusses the scientific uncertainties associated with such findings, (b) analyzes the effects of global change on the natural environment, agriculture, energy production and use, land and water resources, transportation human health and welfare,human social systems, and biological diversity; and (c) analyzes current trends in global change, both human-inducted and natural, and projects major trends for the subsequent 25 to 100 years." The Georgia Water Resources Institute (GWRI) is coordinating the assessment process which involves the above mentioned research institutions. GWRI also conducts part of this research activity, with focus on: (1) assessing the consequences of potential climate changes on the operation of reservoir systems, and to evaluate the effectiveness of regulatory polices in mitigating such consequences (Project 1-ALPHA); (2) assessing the expected changes in regional soil moisture and crop yield over the continental U.S. under various global climate change scenarios (Project 1-BETA).

Methodology

Project 1-ALPHA: this investigation will be conducted for three large multi-objective reservoirs in the US: Lake Folsom in California, Lake Saylorville in Iowa, and the ACF river basin in Georgia (including 4 reservoirs). GCM predictions under present and projected CO2 conditions for several decades have been used to provide forcing for macroscale hydrologic models of the drainage area of the study reservoirs, resulting in daily predictions for precipitation, temperature, and potential evaporation. These parameters have been used in basin scale operational hydrologic models to produce reservoir inflow ensembles, which serve as input in reservoir decision models. Using the latter models, assessments have been performed by comparing reservoir management benefits using GCM output corresponding to present day (baseline) CO2 emissions with output corresponding to projected CO2 emissions. Sensitivity analysis using current operational practices versus adaptive reservoir regulation schemes have been performed to assess the degree to which climate change consequenses can be mitigated through suitable adjustments of reservoir regulation policies. Project 1-BETA: GCM simulations under present and projected CO2 scenarios have been used to provide large scale precipitation and temperature input to macroscale monthly hydrologic models to produce soil moisture estimates over the continental USA. These results have been used to study the character changes in droughts over the record. Agricultural crop models have been used to determine ensembles of crop yields under the various CO2 scenarios.

Principal Findings and Significance

In the reporting period the reservoir decision support models for Lake Folson, Lake Saylorville, and the ACF basin have been developed, and the reservoir inflow ensembles have been generated. A state-of-the-art agricultural model (DSSAT) has been combined with modern regional hydrologic models to provide a direct link between soil moisture estimates and crop yield response. GWRI was a contributor of the Sector Assessment Team which organized a national workshop (Palm Beach, FL, 14-16 September 1998) to gather information on issues and priorities for the study on the potential for climate variability and change in the water sector.

Descriptors

Climate Change Decision Support System Hydrologic Models Reservoir Management

Articles in Refereed Scientific Journals

Forthcoming

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Forthcoming

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Sustainability of Surficial Aquifer Resources on Endmember (Developed and Pristine) Barrier Islands near Brunswick, Georgia
Project Number	B-02-626
Start Date	09/01/1998
End Date	08/31/2000
Research Category	Ground-water Flow and Transport
Focus Category #1	Groundwater
Focus Category #2	Hydrogeochemistry
Focus	

Category #3	Water Quality
Lead Institution	Georgia Institute of Technology

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Carolin D. Ruppel	Assistant Professor	Georgia Institute of Technology	01

Problem and Research Objectives

Three undeveloped barrier islands in coastal Georgia have been mentioned as possible sites for future developments. This has led to interests by regional planners in the impact of urbanization and ecosystem destruction on the hydrologic systems beneath these barrier islands. In fact, the availability and quality of fresh water resources on barrier islands are considered key factors controlling the sustainability of natural systems and human development, as well as the continued viability of ecosystems in adjacent wetlands. The goal of this project is to develop a baseline for monitoring future development related changes in surficial acquifer systems on the concerned islands. The project is scheduled to last two years, of which the first one has now been completed. The following text presents the preliminary results of year 1. It also provides an overview of the planned work for year 2.

Methodology

The framework of the project is to compare the state of the surficial aquifer on a fairly pristine barrier island to that of an aquifer on a heavily urbanized island. Sapelo Island, which has a permanent population of approximately 70 people and is closely controlled by the State of Georgia and NOAA, represents the pristine endmember in this study. Nearly adjacent St Simons Island, which is heavily urbanized, represents the endmember "perturbed" surficial aquifer system. The setup being used for this comparative study has several unique advantages. First, because the islands have exactly the same configuration of Pleistocene and Holocene sediments, marshes, and northern subsidiary islands (Blackbeard and Little St Simons, respectively), this study offers a unique opportunity to use the pristine island to establish a baseline for the state of the surficial aquifer prior to heavy development of St Simons Island. Second, because development on Sapelo Island is located in very localized areas, there is good control on the degree of anthropogenic disturbances in this setting. This allows for the quantification of the impact of these disturbances on the surficial aquifer system in a fairly precise way. The study will collect hydrologic, geophysical, and geochemical data by coupling noninvasive geophysics with standard piezometric measurement and groundwater sampling.

Principal Findings and Significance

To date, the following aspects of the project have been fully or partially completed: 1. Installed a new monitoring well network (3 wells) on the ocean side of Sapelo Island to complete a characterization of the undisturbed state of the surficial aquifer along an approximate across-island transect. 2. Installed new monitoring wells at Moses Hammock, a site used as a hunt camp and equipped with a septic system. The isolated nature of this hammock, a small remnant of Pleistocene sediment wholly surrounded by marsh, makes it possible to develop a relatively complete characterization of the flow

field and of tile impact of anthropogenic disturbances at this site. Also completed are geophysical surveys that directly detected the perturbations to the freshwater system caused by the septic system leachate. 3. Installed farfield wells at the pristine site (Kenan Field) to assist in describing the flow field. 4. Conducted multinode dipole-dipole resistivity surveys to image the subsurface at Moses Hammock and Kenan Field. 5. Completed an across-island GPR profile that provides information about the typical structures controlling local drainage/flow patterns in the shallow subsurface and about the variations in the depth to the water table across the island. 6. Completed a pumping test at the most pristine well network during July 1999 and demonstrated unequivocally that it is possible to stress this shallow aquifer and to pump for extended periods with no concern about (a) pumping the wells dry or (b) pumping saltwater instead of freshwater. Results from this work will be presented at the December meeting of the American Geophysical Union. 7. Completed quantitative grain size analysis of soil samples in the saturated and unsaturated zone at several of the well sites and used these analyses to estimate hydraulic conductivity of the shallow aquifer. A manuscript on this work was submitted in August. 8. Automatically monitored water levels using pressure transducers at two of the well networks. Analysis of the resulting tidal pumping records yields an independent estimate of hydraulic conductivity. 9. Completed 2 independent analyses of groundwater geochemistry. 10. Completed reconnaissance work on St Simons Island. Preliminary Results Among our key preliminary results are: 1. Consistent and independent estimates of the hydraulic conductivity of shallow aquifer sediments in the upland portion of Georgia Bight barrier islands. 2. Preliminary characterization of the nature of the flow field and the interaction of freshwater and saltwater at the tidal creek interface at the anthropogenically-perturbed site on Sapelo Island. 3. Geophysical characterization of the perturbed freshwater lens near the septic field at Moses Hammock on Sapelo Island and of the unperturbed lens on more pristine parts of Sapelo Island. 4. Clear images of the types of subsurface geologic features contributing to local variations in subsurface flow and drainage on Georgia Bight barrier islands. 5. Groundwater geochemical data indicate that weathering and bacterial processes largely dominate the chemistry of the freshwater on Sapelo Island and that waters in wells near the island-estuary interface are nearly equivalent to those in the adjacent tidal creeks. The tidal creeks show higher (but not elevated) levels of compounds (e.g., nitrates) typically traced to anthropogenic influences. With the exception of some wells at the anthropogenically-disturbed Moses Hammock site, only wells affected directly by waters flowing from the adjacent tidal creek show elevated levels of these same compounds. Thus, for a pristine island like Sapelo, compounds like nitrates primarily seem to enter the aquifer through interaction of the freshwater with the tidal creek water at the boundaries. On developed islands, these same compounds first enter the freshwater lens on the island proper, not at its boundary, and are then flushed into the adjacent estuary. Planned Work for Year 2 No major deviations from the original plan are anticipated during Year 2 of the project. Most of the work on St Simons will be carried out from January through March. The project also continues to pursue groundwater samples from existing groundwater wells on St Simons Island. During Year 2, the project plans a complete reanalysis of the groundwater samples from Sapelo Island, possible installation of some wells near a known septic drainage in an area inhabited by research scientists on Sapelo Island, and continued work on understanding the basic aquifer parameters for the Georgia Bight barrier islands. Although not part of the original project proposal, it is hoped to pursue GIS analysis of existing data sets from St Simons Island, in much the same manner as the PI's graduate student has done for Sapelo Island. By early 2000, it is hoped to have enough data for Moses Hammock to permit the application of MODFLOW to complete a preliminary analysis of the flow field.

Descriptors

surficial aquifer system, hydro geology, groundwater hydrology, water quality, anthropogenic disturbances, barrier island

Articles in Refereed Scientific Journals

"Physical Characterization of Shallow Sediments on Sapelo Island, Georgia", by Neal, Ruppel, and Schultz, submitted to Georgia Journal of Science in August 1999.

Book Chapters

Dissertations

Water Resources Research Institute Reports

Ruppel, C. "Sustainability of Surficial Aquifer Resources on Endmember (Urbanized and Pristine) Barrier Islands near Brunswick, Georgia", Progress Report, October 1999, 10p.

Conference Proceedings

Other Publications

The PI co-convened and co-chaired a special session on coastal hydrology at the Spring 1999 meeting of the American Geophysical Union. This session was partially related to work being conducted under the auspices of this grant. In this session, graduate student Gregory Schultz presented a talk entitled, "Mapping and monitoring of spatio-temporal variations in a tidally-forced coastal aquifer system."

Basic Project Information

Basic Project Information	
Category	**Data**
Title	A Decision Support System for the Apalachicola-Chattahoochee-Flint (ACF) River Basin in the Southeastern US
Project Number	
Start Date	12/01/1998
End Date	07/31/1999
Research Category	Climate and Hydrologic Processes
Focus Category #1	Hydrology
Focus Category #2	Management and Planning
Focus Category #3	Drought
Lead Institution	Georgia Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Aris P. Georgakakos	Professor	Georgia Institute of Technology	01

Problem and Research Objectives

This project intends at developing a state-of-the-art river basin planning and management system that can (a) assess the potential of the ACF basin to meet various water uses, and (b) quantify the trade-offs associated with various water allocation scenarios and policies. The purpose of this system is to assist the ongoing tri-state (Alabama, Florida, and Georgia) water allocation negotiation. The project is co-sponsored by citizen groups in Georgia.

Methodology

The decision support system includes a streamflow forecasting module, a set of reservoir control models, and a policy assessment component. The reservoir control models include a turbine commitment and dispatching module (hourly time step), a short range control model (hourly time step), and mid/long range control model using a weekly time interval. The optimization methodology is based on dynamic programming. The third element of the DSS is the policy assessment component used to replicate the actual weekly operations of the ACF-system under various water allocation policies and operations scenarios.

Principal Findings and Significance

In the reporting period a beta version of the ACF-DSS has been made operational and used for extensive testing of the system.

Descriptors

Decision Support System Hydrologic Modeling Policy Assessment Reservoir Operation Drought Management

Articles in Refereed Scientific Journals

Forthcoming

Book Chapters

Dissertations

Water Resources Research Institute Reports

Forthcoming

Conference Proceedings

Other Publications

Basic Project Information

Basic Project Information	
Category	**Data**
Title	Establishment of Satellite Data Aquisition Facility at the GWRI Office
Project Number	
Start Date	12/01/1998
End Date	02/15/1999
Research Category	Climate and Hydrologic Processes
Focus Category #1	Climatological Processes
Focus Category #2	Hydrology
Focus Category #3	None
Lead Institution	Georgia Water Resources Institute

Principal Investigators

Principal Investigators			
Name	**Title During Project Period**	**Affiliated Organization**	**Order**
Aris P. Georgakakos	Professor	Georgia Institute of Technology	01

Problem and Research Objectives

The purpose of the satellite data aquisition system is to estimate rainfall input to watershed models for stream flow forecasting, drought monitoring, and agricultural planning applications. This capability is especially useful in view of the general sparsity of ground data recording stations.

Methodology

The system consists of two receiving antennas, a computer that manages the acquisition of data and their visualization/archiving, and a facility where satellite images are stored for use in research projects. Data are received from geostationary as well as polar orbiting satellites. Geo-stationary satellites can cover North and South America (GOES-8 and GOES-9), and provide data in the visible, near-infrared, water vapor, and thermal infrared bands. NOAA polar orbiting satellites provide high resolution visible, near-infrared, water vapor, and thermal infrared images at every 4 hours. They also provide information on winds and atmospheric pressure over the windows of of coverage. The acquisition and management of the satellite data is accomplished through a SUN UNIX workstation running a software developed by the Seaspace Corporation. Since February 1999, satellite images are stored on tape and on the Storage Tech DLT 7090 archival facility.

Principal Findings and Significance

The images data base is easily accessible and currently used for the development and testing of remote sensing methods for hydrometeorological variables. One such project is the development of an

operational rainfall estimation and flood forecasting system for all major Georgia basins.

Descriptors

Remote Sensing Satellite Based Rainfall Estimation

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

Other Publications

Information Transfer Program

As part of its Information Transfer Program, the Georgia Water Resources Institute (GWRI) organized the following continuous education courses in FY1998: -1: Embankment Dam Design; September 14-16, 1998; 21 participants; -2: Monitoring Dam Safety; October 21-23, 1998; 9 participants; -3: Hydrologic Engineering for Dam Design; October 26-November 2, 1998; 27 participants; -4: Fundamentals of Turbulence Modeling for Engineering Flows; November 12-13, 1998; 10 participants. Also within the framework of the GWRI Information Transfer Program was a seminar presentation by Dr. Georgakakos,"Decision Support Systems for River Basin Planning and Management", NOAA Workshop organized by the Mexican National Commission on Water (Comision Nacional Del Aqua), Mexico City, Mexico, July 7, 1998.

USGS Internship Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	3	N/A	N/A	N/A	3
Masters	2	N/A	N/A	1	3
Ph.D.	N/A	N/A	N/A	3	3
Post-Doc.	N/A	N/A	N/A	N/A	N/A
Total	5	N/A	N/A	4	9

Awards & Achievements

Publications from Prior Projects

Articles in Refereed Scientific Journals

Book Chapters

Dissertations

Water Resources Research Institute Reports

Conference Proceedings

The following publications have resulted from the FY97 project "Effects of Sedimentation on Biodiversity in Rivers and Streams of the Southeastern United States", PI Dr. J.L. Meyer, funded by the State Competitive Grant Program. Barnes, K. H., J. L. Meyer, and B. J. Freeman. 1997. Suspended sediments and Georgia¹s fishes: an analysis of existing information and future research. pp 139-143. In Proceedings of the 1997 Georgia Water Resources Conference. K. Hatcher (ed). Institute of Ecology University of Georgia, Athens, Georgia. J. L. Meyer, A. Sutherland, K. Barnes, D. Walters, and B. Freeman. 1999. A Scientific Basis for Erosion and Sedimentation Standards in the Blue Ridge Physiographic Province. In Proceedings of the 1999 Georgia Water Resources Conference. K. Hatcher (ed) Institute of Ecology, University of Georgia, Athens, Georgia. A. Sutherland, J.L. Meyer, and N. Gardiner. 1999. Effects of Land-Use Change on Sediment Transport and Fish Assemblage Structure in Southern Applachian Streams. In Proceedings of the 1999 Georgia Water Resources Conference. K. Hatcher (ed) Institute of Ecology University of Georgia, Athens, Georgia.

Other Publications