New York State Water Resources Institute
Annual Technical Report
FY 2002

Introduction

Research Program

The New York State Water Resources Institute's (NYSWRI) FY2002 activity under the Federal Water Resources Research Act consisted largely of research and information transfer projects funded during FY2000, FY2001, and FY2002. The FY 2002 Annual Report covers: one FY2000 project and one FY 2001 project from national 104G competitions; one project from a supplemental funding source; three multi-year projects from the FY2001 New York competition; seven projects from the FY 2002 New York competition; and information transfer and student service support by the NYS WRI Director's office.

The FY2000 104G project, covering large watershed nutrient modeling, began in late 2000 and will be completed by the end of FY 2003. The model being developed will predict nutrient loadings to coastal and inland ecosystems. The FY 2001 104G project conducts field and lab experiments and refines simulation models of phosphorus in agricultural settings. Several models have been developed or refined. The models were designed to represent the release of phosphorus from spread manure, to represent spatially distributed moisture dynamics in fields, and to represent the loss of land applied manure in runoff in a patchwork of manured and non-manured fields.

One project funded from a supplemental funding source examines climate and hydrologic processes that affect biodiversity in wetlands. This assists a study of Lake Ontario and St. Lawrence River water level management under the auspices of the International Joint Commission on the Great Lakes (IJC). Funding is provided by the US Army Corps of Engineers through USGS WRD. Literature reviews for five tasks were done and are being used to make predictions about likely future community compositions of the Lake Ontario/St. Lawrence River wetlands as they are affected by water level management. This includes examining the effects of water levels on plant species and breeding waterbirds, as well as concepts and techniques of Ecologically Sustainable Water Management (ESWM).

This year USGS WRD sponsored an internship that supported a student from Cornell's School of Civil and Environmental Engineering. The intern compared water data interpretation guidelines from 1982 to new methods for conducting flood frequency studies.

Seven FY2002 104B projects and three carry-over FY2001 104B projects resulted from in-NY competitions whose topic focus reflected NYS WRI's long-term priority on nonpoint source pollutant management. FY2002 projects covered: methods for evaluating vegetated filter areas for phosphorus removal; predicting dissolved phosphorus losses in overland flow in Northeastern US settings; septic system pollution prevention BMP's with an emphasis on public outreach approaches; community watershed restoration efforts in Catatonk Creek; integrating instream habitat assessment into local watershed management; methods to distinguish between ruminant and human sources of fecal contamination in watersheds; and fostering greenhouse BMP's. FY2001 carryover projects covered:

interactive materials for the Cayuga Lake Watershed Education Program; interactive modeling of stream corridors; and wetland effects on stormwater.

Three FY2002 104B projects will carry over to FY2003. All other FY2001 and FY2002 104B projects were completed. The FY2000 and FY2001 project extend to late 2003. The supplemental IJC project was completed by March 31, 2003.

Evaluation of Vegetated Filter Areas for Phosphorus Removal

Basic Information

Title:	Evaluation of Vegetated Filter Areas for Phosphorus Removal
Project Number:	2002NY1B
Start Date:	3/1/2002
End Date:	2/28/2003
Funding Source:	104B
Congressional District:	NY 26
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Nutrients, Water Quality
Descriptors:	dissolved phosphorus, vegetated filter strips, nutrient management
Principal Investigators:	Larry Geohring, Tammo Steenhuis, Todd Walter

Publication

Problem & Research Objectives:

Phosphorus (P) has been identified as a limiting nutrient in several New York watersheds. In order to achieve the goals of reducing P nutrient inputs to watersheds, various programs and practices are being implemented. Best management practices (BMP's) are often recommended as site-specific measures for reducing contaminant loadings. However, many BMP's are generically adopted based on research conducted in other regions of the United States. For example, vegetated filter strips (VFS) or buffer areas is a BMP that is often recommended. This practice, however, has typically only been shown to be effective in broad, flat landscape settings where soils are deep and runoff moves primarily as sheet flow. In a humid area such as NY, where rainfall is often of long duration at low intensity and where most soils are sloping, shallow or have restricting layers, the effectiveness of VFS is less well understood. Since P can be also transported in dissolved form, the fate of dissolved P through a VFS is perhaps more important. The effectiveness of VFS in removing dissolved P has been controversial, and is not well understood in a New York setting.

The proposed effort will entail a critical review of the literature and the setting from which results are reported, in conjunction with some research in vegetated filter areas. The work will focus on agricultural systems and settings. Specific objectives will be to: 1) Review existing literature regarding dissolved P in VFS, 2) Conduct measurements of dissolved P through vegetated filter areas, and 3) summarize findings incorporating guidelines for improved decision making regarding the use and implementation of vegetated filters for dissolved P nutrient attenuation.

Methodology:

Project Objective 1: Research conducted on laboratory scale or microcosm plot settings of vegetated filters will be reviewed to assess critical variable influences or physical based relationships, but the emphasis will be to find studies on larger scale stream or watershed investigations.

Project Objective 2: The work proposed for Objective 2 will extend current efforts to understand P behavior in soils and in milkhouse grass vegetated filter strips (Murray, 2001). The proposed research will occur on the hillslope scale, with particular emphasis on the near-stream environment. The soil P content will be analyzed for three soil depths (0-5, 5-10, and 10-25 cm) using Morgan's (0.72 M sodium acetate) extraction. Since the project duration is limited to one year, the measured data will be characterized to the season's hydrology and analyzed in accordance with variable constructs based on the review in Objective 1 to determine how well observations fit previously reported results.

Project Objective 3: The findings of Objective 1 and the observations during Objective 2 will be synthesized and summarized into a report structured to facilitate further decision making regarding the use of vegetated filters as a BMP.

Principal Findings & Significance:

We reviewed numerous publications on vegetated filters or buffer areas yet there still seems to be a large gap in understanding of the associated complex biogeochemical cycling of phosphorus (P). There is a growing body of evidence on the mechanisms controlling P transformations but few data addressing the rates and limits of these processes. These gaps in the knowledge base

limit the ability to model, or better evaluate experimentally P-cycling in the landscape. We found numerous examples of different terminology in the literature (i.e., field borders, contour grass strips, grassed waterways, grassed hedges, vegetative barrier, vegetative screen, filter strips, shelter belts, non-disturbance area, riparian buffer zone, infiltration galley, and wetland) which simultaneously confuse buffer discussions and add some clarification on the form of P to be controlled and the mechanisms based on the landscape position. In general, vegetated filters are quite effective in the physical processes of deposition and filtration, removing particulate P (PP) or organically bound P as long as there is shallow, uniform flow across the area. Suggested filter widths vary from a few meters to several hundred meters usually based on the land slope, vegetation type, and particle grain size. However, vegetated filters serving as a sink for particulate forms of P, are often reported as a source of dissolved P (DP) or bioavailable P following biological and chemical transformations and subsequent hydrological events (Uusi-Kamppa *et al.*, 1996; Correl, 1999; NRC, 2002). Unsaturated upland vegetated filter areas, where infiltration can occur into soils high in organic matter, aluminum and iron oxides, and calcium, can be effective at removing both PP and DP. Infiltration into sandy or peat soils which have little potential for adsorption and precipitation of DP are not truly effective P sinks, although several articles claim a 100% P removal because all the surface water was infiltrated. Vegetated filters in areas with fluctuating degrees of saturation, even those containing DP adsorptive soils, often release P upon wetting as a result of anaerobic or reducing P transformations. Areas where saturation conditions prevail, such as riparian buffers along gaining streams and wetlands, were often reported to be effective at trapping PP, only to release it later as DP. As a result, the benefits of implementing vegetated filter areas to remove P vary widely. We found a range of –114 to 100 percent reductions in P concentration for the variety of vegetated filters described in the literature. Overall, the retention of DP is much less efficient and more difficult to achieve compared to PP, and in some cases, losses of DP were increased.

We found in the literature that P assimilation by vegetation is temporal and appears to have little long-term effect in P removal. Although rapidly growing plants may uptake as much as 40 kg P/ha/yr, most of this is recycled to the vegetative filter strip in decaying plant residue. Several authors claim that biomass harvesting and removal was not a very significant P removal mechanism compared to the P loading used. Rapidly growing willows, sweetgum and red maple trees can take up about 10 kg P/ha/yr, but approximately 8.3 kg P/ha/yr is returned as leaf litter and throughfall (Adegbidi *et al.*, 2001; Peterjohn and Correll, 1984). Consequently, forest vegetated areas may only have minimal long-term removal amounts during growth. The microbiological activity of the soil can also utilize and extract P, but again most of this is recycled within a vegetated filter area during the endogenous stage. A large body of literature reports on the effectiveness of trapping eroded materials and sediments (i.e., PP) with different types of plants, and some models have been developed for this purpose (Inamdar *et al.*, 1999; Munoz-Carpena and Parsons, 2000). However, several of these same studies acknowledge that there are physical limits to the amount of deposition, and that usually sediment bound P is eventually re-entrained or bio-chemically transformed into DP that can be transported in subsequent hydrological events. Concentrated flows limit deposition of PP or find new paths through previous depositional areas reducing the effect of vegetated filters. Concentrated flows are prevalent in humid and high-topographic relief areas such as the Northeast.

Vegetated filter areas that can effectively reduce DP concentrations will be an important component to reducing surface water quality impairments attributed to excessive P loading.

Surface runoff from agricultural and urban nonpoint areas can contain from 10 to 45% P in the DP form (Pietilainen and Rekolainen, 1991; Cowen and Lee, 1976; Scott *et al.*, 1998). Point sources such as milk house, barnyard runoff, pulp/paper mill wastewater, and secondary treated municipal wastewater can contain from 65 to 85% of the total P as DP (Schwer and Clausen, 1989; Schellinger and Clausen, 1992; Priha, 1994).

We hypothesized that vegetative filters are less effective at reducing DP when preferential flows occur or under wet and fluctuating soil saturation conditions. We carried out experiments in a vegetated filter area receiving milk house wastewater and also in a natural vegetated riparian buffer between a manured cornfield and a stream. We found that preferential or concentrated flow paths occurred in both these settings, despite the installation of a level-lip spreader board to diffuse the flow in the milk house vegetated filter. The milk house vegetated filter was generally unsaturated, and soil tests revealed that the soil had sufficient capacity to adsorb P based on the presence of aluminum and iron oxides. Where the wastewater flow infiltrated, the DP concentration was reduced from an average of 9.1 to 0.8 mg/l over a distance of 36m. Wastewater that flowed over the surface had DP concentrations ranging from 13.7 to 5.9 mg/l over the same 36m. The milk house wastewater that was applied had an initial average concentration of 15.8 mg/l of DP. For this case, the reduction in DP concentration was best fitted to an exponential decay function (Geohring *et al.*, 2003). In the natural vegetated riparian buffer, the DP concentration was reduced from an average of 0.11 (at edge of manured corn field) to 0.07 mg/l (next to the stream) over a 38m distance, when the flow was primarily subsurface. However, during a wet period, the DP concentration went from 0.72 to 0.15 mg/l across the 38m distance. The wet period produced some concentrated flow and raised the water table in the natural buffer, ultimately increasing the concentration immediately adjacent to the stream. The estimated shallow lateral flow DP loading to the stream in this situation, based on the soils hydraulic conductivity in the riparian area, is 0.008 g/d per square meter streambed interface. In both experiments, the explicit hydrology influenced the observed DP concentrations and potential transport rates.

The literature review and experimental findings suggest that in order for vegetated filters to effectively reduce DP, they need to be placed in an unsaturated part of the landscape and consist of soil which can geochemically adsorb and fix P. The water needs to be introduced to these areas such that it is distributed uniformly, and minimizes soil saturation and surface runoff. Any preferential flow through the profile, or concentrated flow across the surface reduces the residence time required for the kinetic biochemical adsorption reactions. Vegetated filters or riparian areas located next to gaining streams for the purpose of trapping PP, may put P enriched sediments in a high risk location because the rising water table creates anaerobic conditions which can transform P to soluble forms.

Notable Achievements:

The results of this work have generated considerable interest on behalf of conservationists, engineers, and practitioners interested in the design and application of vegetated filter strips to control point and nonpoint sources of pollution in agricultural settings. We've been invited to present findings at the East Regional (includes Northeast and Mid-Atlantic states) USDA-NRCS Technical Workshop, and a presentation was delivered to the NY-NRCS Training program. Fifty people have signed up for a Filter Areas session at the NYS S&WCC 2003 Water Quality Symposium.

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Predicting Dissolved Phosphorus Losses in Overland Flow in Northeastern U.S.

Basic Information

Title:	Predicting Dissolved Phosphorus Losses in Overland Flow in Northeastern U.S.
Project Number:	2002NY2B
Start Date:	3/1/2002
End Date:	2/28/2003
Funding Source:	104B
Congressional District:	NY 26
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Nutrients, Surface Water
Descriptors:	dissolved Phosphorus, Nutrient management, runoff
Principal Investigators:	Tammo Steenhuis, J.-Yves Parlange, Michael Walter

Publication

1. Gao, B.; M. T. Walter; T. S. Steenhuis; J.-Y. Parlange; K. Nakano; W. L. Hogarth; C. W. Rose. 2003. Investigating Ponding Depth and Soil Detachability for a Mechanistic Erosion Model using a Simple Experiment, Journal of Hydrology.

Problem & Research Objectives:

On May 24, 1999, the U.S. Department of Agriculture (USDA)-Natural Resources Conservation Service (NRCS) adopted a policy that requires the use of a P index or comparable vulnerability assessment techniques when developing nutrient management plans (NMP) for concentrated animal feeding operations (CAFOs) or for other farms near P sensitive reservoirs, lakes and streams (Lander, 1999). A major limitation in the implementation of the P index for NMPs is the poor scientific understanding of the transport of dissolved phosphorus (P) into runoff water from agricultural and forests lands. Most of the previous research on the fate of P in the agricultural landscape was directed towards supplying P to crops for optimal growth. Moreover, it was assumed that P loss in runoff was only in the particulate form because of the strong P adsorption properties of most soils. However, many recent studies have confirmed the findings of Hergert et al. (1981) that it is not only particulate P (PP) that is lost but that also dissolved P (DP) is a significant part of the total P losses in the agricultural runoff water. Consequently, improved understanding of the amount of DP loss in runoff will greatly enhance P loss prediction techniques, such as the P index method. Better understanding of DP losses will also help in the selection of effective best management practices (BMP).

The overall goal of this project was to improve P loss prediction techniques for variable source, saturated areas located in agricultural landscapes. The particular goal was to systematically derive a predictive relationship for the concentration of DP in the runoff water based source factors such as soil type, the amount and type of P in the soil, climatic factors including rainfall amount and energy, and landscape factors including initial moisture content, ponding depth and rate of upward and downward flux. The project will ultimately lead to more physically robust P index tools for the unique soils and conditions in the Northeast, an improved understanding of P fate and transport processes, and improved decision making regarding P control and management practices applicable to these conditions.

Methodology:

The experimental methods and set-up were derived from a study in which the upland erosion component of the Rose and Hairsine model was validated (Heilig et al., 2001; Gao et al., 2003). The experimental apparatus was, in principle, very simple and is designed to isolate the soil, climate, and landscape factors that contribute to the P loss in runoff water. Rainfall was simulated using a computer-controlled rainmaker that oscillated simultaneously along two orthogonal tracks. Each experiment consisted of carefully establishing a flat soil surface with a predetermined amount of ponded water followed by application of rain.

In the early studies by Heilig et al. (2001) and Gao et al. (2003), we found that the Rose and Hairsine model predicted the sediment concentration in runoff water very well. The model assumed that the fine particles loosened by the rain splash were removed preferentially in the runoff water resulting in a shield of coarse particles near the surface with a depth of approximately 0.5 cm.

The hypothesis for this study was that the loss of the fine particles due to raindrop splash is similar to the loss of the DP from this surface layer due to raindrop impact.

Only a selected set of the climate, soils, and landscape factor interaction were investigated during this short, one-year study. In the first two experimental sets, the mechanisms that contribute to

the P loss in the runoff water were be quantified and the results were used to adapt the Rose and Hairsine upland erosion model for DP loss.

Principal Findings & Significance:

Unexpectedly, we found that solute transport between the soil matrix and runoff is fundamentally different from the transport of small particles (e.g., clay). Clay particles are entrained into runoff by raindrop impacts and the rate of entrainment slows and eventually ceases as a shield layer of heavy particles develops across the soil surface. The initial solute entrainment rate was much more rapid than for clay and as the rainfall continued the entrainment rate slowed to a constant, non-zero level. We hypothesized that the early, rapid entrainment period was also controlled by raindrop impacts and ultimately the entrainment rate was controlled by diffusion from deep soil layers. We successfully tested this new hypothesis for how solutes move between soil and runoff water by developing a quantitative model and testing against experimental data. This new description of solute transport challenges the widely used, traditional "diffusion" (Wallach et al. 1988) and "mixing layer" (Steenhuis and Walter 1981) models. We found that an acceptable solution for our hypothesized process takes a mathematical form similar to the Rose soil-erosion model and that we can use erosion parameter determined by the Rose model to help understand the role of raindrop impact on solute transport between soil and runoff.

We demonstrated the importance of raindrop processes by developing a simple model for predicting soil solute loss to overland flow that combined rain impact physics with the diffusion theory developed by Wallach et al (1988). We showed that the raindrop detachment effect, which was ignored in previous studies and commonly used models, plays an important role during the solute transport process. Furthermore, our new model also fits previously published data by Ahuja et al. (1981), that has been used in many widely cited investigations. We have improved our understanding of the physical processes involved by developing a numerical model, which also agreed with our experimental data and previously published data. The numerical model allowed us to develop a simpler, more accurate form of our original model.

We carried out several experiments studies to comparing non-sorbed chemical transport to DP (a chemical that sorbs to soil) transport. The experimental data suggested that the adsorption-desorption processes of soil on DP transport can be largely simplified in the modeling process by assuming a constant adsorption and desorption partition coefficient. This method is similar to that which was successfully applied to predicting of preferential flow solute concentrations by Steenhuis et al. (1994). We demonstrated that our new model predicts both sorbing (i.e., DP) and non-sorbing chemical transport between soil and overland flow for various rainfall intensities and soil types.

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Septic System Pollution Prevention BMPs: Development of Public Outreach Approaches, Assessment, and Decision-Making Tools for Local Government

Basic Information

Title:	Septic System Pollution Prevention BMPs: Development of Public Outreach Approaches, Assessment, and Decision-Making Tools for Local Government
Project Number:	2002NY3B
Start Date:	3/1/2002
End Date:	8/31/2003
Funding Source:	104B
Congressional District:	NY 29
Research Category:	Water Quality
Focus Category:	Waste Water, Treatment, Water Quality
Descriptors:	septic systems, water quality, pathogens
Principal Investigators:	Kim Irvine, Sherry Fontaine

Publication

Problem & Research Objectives: Irvine and Pettibone (1993) found that bacteria sources in the upper watershed (a mix of forest, agriculture, rural residential, and small town land uses) potentially had a greater impact on water quality than the CSOs. Subsequent projects (Irvine and Pettibone, 1996; Wills and Irvine, 1996) confirmed that upper watershed sources, particularly in association with storm events, produced high levels of fecal coliforms in the three major tributaries to the Buffalo River (often in the range of 10,000-30,000 cfu/100 mL). One of the principal bacteria sources in the upper watershed appears to be failing septic systems.

Although septic systems appear to be an important bacteria source within the upper watershed, tools/approaches have not been developed to assess problems within specific reaches or the potential effects of improved septic practices on water quality. The proposed research will assist Erie County in refining its outreach regarding septic practices, assess the effectiveness of such outreach, and provide decision-making tools to evaluate the effects of septic system programs on receiving water quality.

The objective of the research essentially is to develop a program that optimizes public outreach and decision-making on a watershed basis and thereby maximizes water quality benefits from implementation of septic system BMPs. The research will focus on two areas, one being the delivery and assessment of a county level outreach program related to appropriate septic construction and maintenance; and the other being application of computer-oriented tools (GIS, remote sensing, water quality modeling) to help county personnel identify problem source-areas and evaluate the potential impact of septic remediation on receiving water quality.

Methodology:

One workshop on proper septic system construction and maintenance already has been sponsored by the Erie County Water Quality Coordinating Committee and its member agencies. A short video produced by Cornell University started the program and provided the participants with a basic understanding of their system. The information was augmented with three short presentations addressing soil considerations, septic system design and standards, health implications of failing systems, causes of septic failure and how to recognize problems, and the costs associated with installation, replacement and repair.

A survey instrument will be developed and mailed to assess attitude and changes in behavior that can be associated with workshop participation. Data on attendee perspectives regarding the type of assistance that would help ensure appropriate and safe septic practice (including the necessary level and type of assistance), intervention models, and future needs also will be collected, analyzed, and widely disseminated for discussion and planning purposes.

Through this proposal, two additional septic workshops will be held in fall, 2002, and spring, 2003, with an identical format to the Cazenovia Creek workshop.

A web page will be added to the Erie County DEP home site that provides general information about septic systems as well as the literature distributed at the workshops in an Adobe Acrobat readable format.

Bacteria Source Assessment Tools. As a first step in identifying potential source-areas of septic system discharge, ArcView GIS will be used to identify areas within the Buffalo River watershed that are serviced by municipal/county treatment plants and those that are not.

Locations of the septic source-areas will be input to a mathematical model to evaluate septic abatement scenarios.

As part of a different project, our group already has calibrated the hydrologic component of the NPSM/HSPF model for each of the three tributaries using observed daily mean flow data from USGS gauge stations for three different years (1990, 1992, 1995) with satisfactory results (Perrelli and Irvine, 2001). In the proposed work, we will review the literature to determine representative flow rates from individual septic systems.

Principal Findings & Significance:

The project is ongoing and has been granted a no-cost extension until August 31, 2003. The following are highlights of work that has been completed and work remaining:

Our workshop assessment questionnaire was developed, in consultation with the Erie County office of the Natural Resources Conservation Service, Erie County Health Department, Erie County Department of Environment and Planning, and Erie County Soil and Water Conservation District.

Our first septic system workshop was conducted in the town of Sardinia on the evening of November 19, 2002 and it was attended by a total of 60 area citizens. The assessment questionnaire was distributed to the attendees and they were asked to complete it and hand it in at the end of the workshop. We asked that only one questionnaire be completed per family and a total of 24 questionnaires were returned that evening.

The Erie County Water Quality Committee had sponsored septic system workshops in other towns of the Buffalo River watershed during the past year and a half, prior to the development of our assessment questionnaire. We obtained the sign in/mailing list of attendees for the previous workshops and mailed our questionnaire. The list contained 80 names/addresses and to date we have received 46 completed questionnaires and 3 mailings were returned as undeliverable.

We have entered the questionnaire responses into an Excel spreadsheet and have begun summarizing results.

As a first step to developing the modeling tool for the bacteria loading estimates from septic systems in the Buffalo River watershed, we have identified buildings and their characteristics (e.g. floor space and/or number of bedrooms) within a 300 ft. buffer around the tributary streams within the watershed. Septic system discharge permit information for the commercial, industrial, and institutional facilities within the 300 ft. buffer have been obtained from the NYS DEC. Loadings from residences to their septic systems will be estimated based on a literature review that identified per capita/per bedroom wastewater discharge volume per day and a representative range for fecal coliform level.

As noted in our proposal, the hydrologic component of the BASINS version of NPSM/HSPF had previously been calibrated. This calibration was done using BASINS version 2 and we have updated all files to run in BASINS version 3. BASINS will be used to route

bacteria loadings through the tributaries to determine the potential impact of different septic system abatement options on water quality.

Remaining Work:

Conduct our second and final septic system workshop and apply the assessment questionnaire. This workshop will be held in the town of Alden at the end of March.

Complete the analysis of the assessment questionnaires.

Complete the septic system abatement scenario analysis using BASINS and train Erie County Department of Environment and Planning personnel to run the model.

Construct the informational web page in association with Erie County Department of Environment and Planning.

Complete the final report.

Students working on the project will present results at the Great Lakes Regional Pollution Prevention Roundtable meeting, Erie, PA, in early August.

References:

Irvine, K. N. and G. W. Pettibone. 1993. Dynamics of indicator bacteria populations in sediment and river water near a combined sewer outfall, Buffalo River, New York. *Environmental Technology,* 14: 531-542.

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Wills, M. and K. N. Irvine. 1996. Application of the National Sanitation Foundation Water Quality Index to the Cazenovia Creek pilot watershed management study. *Middle States Geographer,* 29: 95-104.

Supporting Community Watershed Restoration Efforts in Catatonk Creek

Basic Information

Title:	Supporting Community Watershed Restoration Efforts in Catatonk Creek
Project Number:	2002NY4B
Start Date:	3/1/2002
End Date:	8/31/2003
Funding Source:	104B
Congressional District:	NY 26
Research Category:	Water Quality
Focus Category:	Hydrology, Water Quantity, Water Quality
Descriptors:	flooding, water quality, streambank erosion, hydrology, education
Principal Investigators:	Joseph Graney, James Curatolo, Karen Salvage

Publication

Problem & Research Objectives: The headwaters of the Susquehanna River within New York State are characterized by excessive flooding during major storm events and spring snowmelt. The terrain within the Upper Susquehanna River sub-basins includes rolling hills with steep walled side valleys that focus runoff to feed the main river flows. Readily erodible glacial deposits are present along streambanks and blanket the shale bedrock in upland areas. Because of the steep gradients and glacial till deposits, the feeder streams can carry large sediment and gravel loads resulting in streambank erosion, sedimentation, gravel deposition and flooding. This project will explore these issues within the Catatonk Creek watersheds in Tioga and Tompkins County, New York in collaboration with personnel from the Upper Susquehanna Coalition.

The Upper Susquehanna Coalition is a grass roots based organization of county natural resource professionals that provide technical support to local stakeholders. This project provides a mechanism to add an academic component to this partnership to help inform and educate the citizens groups about the physical and chemical hydrology within their watersheds.

Objectives:

- Continue assessments of the Catatonk Watershed to document potential project sites for wetlands construction
- Compare physical and chemical hydrology within two adjacent Catatonk watersheds (Miller Creek and Sulfur Springs) that experience differences in sediment loading and stream flow on a storm event and seasonal basis.
- Provide baseline data for a watershed hydrological model to aid in selecting effective implementation projects to determine how effectively they might modify flows associated with flooding
- Use the information gathered to develop at least one implementation proposal to address flooding/erosion issues

Methodology:
Comparative hydrology within the Miller Creek and Sulphur Springs sub-basins within the Catatonk Watershed is being assessed using GIS based tools in conjunction with measurement of water quantity and quality parameters.

The USC and Penn State University have developed an ArcView GIS-based assessment tool for stream corridor problems and wetland development potential. The tool manages data, maps and photographs in an interactive format. The USC and Binghamton University students are using this tool to continue assessments within the Catatonk Creek Watershed.

The USC have deployed a continuous rainfall gage and five flow meters (stream height gages) in high priority tributaries to collect pre-construction flow information. Based on the results of the summer 2001 flow measurements within Catatonk Watersheds, we are collecting water and suspended sediment samples on a "significant event basis" schedule using automated stormwater runoff samplers at two of the flow measurement sites near the mouth of the Miller Creek and Sulfur Springs sub-watersheds. Base flow sampling is also ongoing in these watersheds on a bi-weekly basis. Normal water chemistry parameters (i.e. temperature, pH, conductivity) as well as metal concentrations are being assessed. The stream height and gages in conjunction with manual flow velocity and volume measurements are being used to construct stream rating curves.

All of this information is being used for input and calibration within hydrological models based on Watershed Modeling Systems (WMS) interfaces.

Principal Findings & Significance:

Data collection and generation for this project is part of an ongoing effort to study hydrology and sediment sources within the Catatonk Creek watersheds in order to collect baseline data to help predict effects prior to wetland construction.

Data collection began in June 2002 and will continue through May 2003. Significant findings can not be elaborated upon in detail until the entire year of data has been collected and analyzed. However, preliminary observations indicate surface flow is ephemeral in Sulfur Springs but sustained year round in Miller Creek. Sediment loading is of much greater concern in Sulfur Springs than in Miller Creek. Water levels in Sulfur Springs respond more quickly and are more flashy after storm events than the response in Miller Creek. Part of the controls for the hydrologic differences between the adjacent watersheds is due to differences in topographic gradients in the two watersheds, especially near the mouths of the watersheds.

Based on the results from this project, wetland construction is being planned within the Sulfur Springs sub-watershed in an effort to reduce peak flows, sustain base flow and alleviate erosion problems. No wetland construction is planned for Miller Creek. Miller Creek will continue to be monitored in order to provide an unperturbed watershed in order to document hydrologic effects from wetlands construction in the adjacent watershed.

Notable Achievements:

Several proposals have been submitted that have used ongoing data collection from this project in order to acquire baseline information for future studies. Work on this project has resulted in a collaboration with the USC on a proposal submitted in fall 2002 for the EPA Watershed Initiative that includes work in the Catatonk and other watersheds in the Upper Susquehanna for integrated ecosystem based studies; this proposal was chosen for funding. We are also presently working with the US Army Corp of Engineers to leverage results from this project to scope out a workplan for a long term hydrologic study before, during and after wetlands construction in Catatonk watersheds. Both of these efforts have allowed us to meet the goal of proposal generation outlined within the project objectives.

Demonstration of Integrating Instream Habitat Assessment into Local Watershed Management

Basic Information

Title:	Demonstration of Integrating Instream Habitat Assessment into Local Watershed Management
Project Number:	2002NY6B
Start Date:	3/1/2002
End Date:	2/28/2003
Funding Source:	104B
Congressional District:	NY 26
Research Category:	Biological Sciences
Focus Category:	Ecology, Conservation, Methods
Descriptors:	aquatic habitat, stream ecology, methods, ecosystem management, monitoring
Principal Investigators:	Piotr Parasiewicz, Clifford Kraft

Publication

Problem & Research Objectives: Hydrological and habitat modification has been recognized by the US Environmental Protection Agency (EPA) as one of major contributors of non-point source pollution. It is a strategy of the NYS Nonpoint Source Management Plan (page V-45) to improve water quality and restore instream and riparian habitat as a part of maintenance and operation of existing modified channels. The majority of methods used for instream and riparian habitat restoration are constrained in their capability to quantitatively assess the biological response to water withdrawals, channel modification, pollution, and dam removals. Consequently, local and regional management agencies need watershed management tools with the capacity to predict the biological consequences of hydro-modification and applied restoration measures while optimizing the level of required technical resources.

Our overall goal is to assist communities in building more sophisticated environmental resource protection programs, and to enable communities to look beyond single issues to consider the total ecological health of their landscape.

Our specific objectives are:

1) Implement quantitative instream habitat assessment and modeling as a method of Instream and Riparian Habitat Restoration Management Measures (EPA-Non Point Source pollution task);

2) Incorporate instream habitat protection objectives into watershed management activities by local governments and not-for-profit organizations;

3) Provide a quantitative science-base for instream habitat in order to develop a management concept;

4) Demonstrate the procedures in selected watersheds in NYS;

5) Increase the understanding of agency staff and the lay public as to the functions and values of stream ecosystems;

Methodology:

We are proposing a project to demonstrate the application of a newly developed instream habitat modeling technique (MesoHABSIM) to integrate aquatic habitat management, flood protection and water quality protection. In this process of know-how transfer to the local citizen group and local state agency, we will help to provide an instream habitat knowledge-base for establishing ecological goals pertaining to an integrated management concept developed for the watershed.

Principal Findings & Significance:

There were the following principal findings:

- Technology is easily transferable to local groups. The technicians and volunteers are capable of stream mapping after minimal training, providing high quality data. Our method is highly educational and develops an ecological perception of aquatic ecosystems.
- Due to limited and irregular time availability, the volunteers can fulfill only supportive roles in habitat projects. One technician is necessary to assure constant progress and data quality.

- The major limitation in model applicability is fish data collection. Development of a library of transferable habitat response functions is necessary to allow the wide distribution of methods.

Notable Achievements:

We could successfully demonstrate the technology to two groups of end-users: local government agency -- Greene County Soil and Water Conservation District in Cairo, NY (GCSWCD), and citizen volunteer groups - Pomperaug River Watershed Coalition (PRWC). The groups were very different as the staff of GCSWCD was highly skilled and technically advanced, where as the volunteers consisted of people with different backgrounds and limited time availability. Nevertheless, we successfully performed habitat evaluations of the Stony Clove and Pomperaug Rivers. The main difference was in the progress of the studies. On the Stony Clove, we conducted a full fishing survey, and three consecutive habitat mapping campaigns of 9 river miles. On the Pomperaug River, 35 miles of streams were mapped once. The project demonstrated the applicability of the technique at the local level as well as its strong educational component. The obtained data are presently used for the development of a stream management plan for both watersheds.

Development of Methods to Distinguish Between Ruminant and Human Sources of Fecal Contamination in Watersheds

Basic Information

Title:	Development of Methods to Distinguish Between Ruminant and Human Sources of Fecal Contamination in Watersheds
Project Number:	2002NY7B
Start Date:	3/1/2002
End Date:	2/29/2004
Funding Source:	104B
Congressional District:	NY 21, NY 22
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Waste Water, Water Quality
Descriptors:	fecal contamination, water quality management, Bacteroides
Principal Investigators:	Karen Sklenar, Ellen Braun-Howland

Publication

Problem & Research Objectives:

In order to reduce fecal contamination of water bodies, watershed managers first need to identify the sources of the contamination. Traditionally, results of fecal coliform and fecal streptococcus testing have been used. Since these groups are found in both humans and other mammals, watershed managers look to the ratio of fecal coliform to fecal streptococcus as a possible indicator of the source of contamination. Unfortunately, this is not a reliable approach for several reasons (APHA, 1998).

The objectives of the project are:

1)To assess the effectiveness of the Bacteroides PCR test, coprostanol, and caffeine at identifying sources of fecal contamination in watersheds;

2)To compare the sensitivity of the Bacteroides PCR test, coprostanol, and caffeine with more established indicators of fecal contamination (total coliforms, fecal coliforms, E. coli, fecal streptococcus, enterococcus) under different seasonal and land use conditions;

3)To conduct a preliminary evaluation of the effect of agricultural best management practices on water quality downstream of farms in Albany and Rensselaer Counties.

The project will focus on the collection and analysis of samples collected from several stream stations in Albany and Rensselaer Counties.

Methodology:

For this project, we propose to assess the ability of a new, molecular-based PCR method to identify sources of fecal contamination in watersheds. This method identifies fecal contamination through the amplification of *Bacteroides* DNA. This method, while being able to identify the presence of fecal contamination, is exceptional due to its ability to quickly and efficiently identify the source of contamination as being human or ruminant.

Principal Findings & Significance:

Investigators worked closely with representatives from the Albany and Rensselaer County Soil and Water Conservation Districts to identify stream stations that would be used for the study. In the cases where streams were located downstream of farms, the farmers were consulted and their approval was obtained before a station was selected for the study.

The specific locations of the stations that are being used for this study are blind, both in terms of when results are reported, and for the investigators when they perform the laboratory analyses. Instead of their specific identity, stations are assigned alpha-numeric labels and categorized by their upstream land use.

The first round of sampling was collected in July 2002 over four days. The samples collected were considered representative of summer, low flow conditions. Samples from the second sampling, conducted in November, were considered representative of moderate flow conditions. Twelve stations were sampled, with triplicate samples collected at each station. The breakdown of sampling stations is as follows:

- Three stations downstream of CAFOs with no BMPs in place

- Two stations downstream of CAFOs with BMPs in place
- Three stations draining a combination of farms and residential areas with septic systems
- Three stations downstream of septic systems considered failing or poorly sited
- One station downstream of forested land with neither farms nor residences upstream

The July and November samples have been analyzed for all of the parameters, although investigators are still in the process of analyzing for species-specific *Bacteroides.* The winter sampling is scheduled to take place as soon as conditions allow.

Statistical analysis of results has not been conducted yet, so findings reported here are general observations of the data rather than results of robust statistical analyses. A summary of results on the basis of analytical data available to date is as follows:

- *Bacteroides,* caffeine, and coprostanol were detected in many of the samples collected
- Triplicate samples used for microbiological analyses collected at the same stations seem consistent with one another
- Total coliforms were high in all of the samples, regardless of station location, including the "pristine" control
- Fairly high numbers of *E. coli*, fecal streptococci, enterococci, and fecal coliforms were found in all but the pristine site's samples
- There is not an apparent relationship between land use upstream and fecal coliform/fecal streptococcus ratio

Notable Achievements:

Excellence in Research Award, University at Albany, School of Public Health, for poster describing this research.

International Lake Ontario and St. Lawrence River Study: 2001 Environmental Program

Basic Information

Title:	International Lake Ontario and St. Lawrence River Study: 2001 Environmental Program
Project Number:	2002NY19S
Start Date:	9/1/2001
End Date:	3/31/2003
Funding Source:	Supplemental
Congressional District:	26
Research Category:	Biological Sciences
Focus Category:	Hydrology, Ecology, Wetlands
Descriptors:	hydroecology, water regulations, hydrologic regulation criteria, biodiversity, habitat quality, ecosystem processes, wetlands
Principal Investigators:	Mark Bain, Sandra Bonanno, James Gibbs, Lee Harper, Donald Leopold

Publication

1. Steen, David; James P. Gibbs, 2002, Interactions Among Waterbird Diversity, Wetland Characteristics, and Water-Level Management in the Lake Ontario/St. Lawrence River Region: A Synthesis of the Published Literature, Final Report to the US Army Corps of Engineers/International Joint Commission, SUNY-ESF, 83 pages.
2. Kelshall, Nathan; Donald J. Leopold, 2002, Literature Review: Effect of Water Levels and Water Level Fluctuations on Wetland Plant Growth, Survival and Germination: Emphasis on Lake Ontario and Saint Lawrence River Coastal Wetland Plants, In Fulfillment of an International Joint Commission Grant, SUNY-ESF, 129 pages.

Problem & Research Objectives:

In 1999 the International Joint Commission (IJC) informed the governments of the United States and Canada of its establishment of a binational study to review the criteria which presently prescribe the way in which Lake Ontario water levels are regulated. A Study Board was assembled by the IJC to investigate a range of benefits and consequences of the operation of control structures influencing flows and levels of the Lake Ontario - St. Lawrence system. With study results, a determination will be made as to which changes are warranted in the operating criteria of the regulatory works on the St. Lawrence River to better answer the needs of different interest groups. The Study is divided among working groups for public interests, environment, recreational boating, commercial navigation, riparian property, hydropower, common data needs, plan evaluation, and water use.

In 2001-2002, the Environment Technical Work Group will focus on (1) wetland vegetation studies and mapping to provide recommendations on the regulation scenarios to maintain dynamic cycles and processes, (2) faunal studies to protect significant habitat in coastal waters for fish and bird communities; and (3) modeling and integration of data to obtain preliminary outcomes of different regulation scenarios on all Environmental attributes. The Technical Work Group will use the first year efforts to design subsequent investigations and analyses. This package includes all non-federal agency studies under the Environment Technical Work Group plan approved by the Study Board in June 2001.

The goal of this International Joint Commission (IJC) Environmental Work Group task is to produce an initial impact assessment model for mathematical application to the evaluation of different water regulation plans. While developing a first assessment model will require speculation on some environmental resources, this exercise will achieve the following objectives:

1. Demonstrate a specific assessment method in working form.
2. Identify information needs to support a specific assessment method in a way that can guide future efforts by the work group.
3. Demonstrate specific information needs to be developed by contractors in the current year and in future years.
4. Resolve precise relations between environmental response information and the hydrologic simulation capability of the Hydrologic and Hydraulic Modeling Technical Work Group.
5. Demonstrate outputs of the Environmental Work Group for inclusion in systemwide evaluation.

Methodology:

This proposed project is to allow a lead scientist with extensive impact assessment experience to work with an environmental specialist to design, structure, and parameterize a numeric model for expressing environmental gains and losses under different water management plans. These specialists will work with the office of the Canada Environmental Lead (C Hudon) and members of the Environmental Technical Working Group. Very close working relations will occur with

2001 contractors and the Hydrologic and Hydraulic Modeling Technical Work Group leads. In addition to one on one sharing of information and knowledge, project scientists will organize and hold two workshops of 2001 contractors (travel at their cost). The first in late winter 2002 will be held to identify the criteria for environmental resources to be in the model. For example, vegetated underwater habitat area might be a criteria for parameterization while a resource concern like fish habitat would be too general. In addition, the data and information being collected in 2001 would be compared with available information to assess what is needed to parameterize each criteria. The product of this workshop would be a list of criteria, how they would be used together, and what information is at hand for parameterizing each criteria. The second workshop would be afterward for the purposed of parameterizing the criteria selected for modeling. Participants will again be environmental contractors and work group members. The product of this workshop will be a parameterized model with professional judgments used when no clear information exists. Afterward, the model would be made operational through interaction (small meeting of specialists) with the hydrologic simulation contractors of the Hydrologic and Hydraulic Modeling Technical Work Group. The final product of this proposed effort will be a report of the model structure, application techniques, and draft results of use in the initial assessment exercise. The most pressing information and data needs will also be identified.

Principal Findings & Significance:

Literature reviews were done on all specific study areas.

With regard to the native and exotic plant species studied, simple graphic models were developed that show the relationship between plant species and water depths and flooding duration. The results of the literature review can be used to make predictions about likely future community composition of a Lake Ontario/St. Lawrence River coastal wetland given knowledge of the present community composition and the future hydrologic regime.

With regard to water birds including waterfowl, the goal was to analyze how intrinsic and extrinsic variables influence the presence and relative abundance of waterbird guilds and thus establish the relationship between key wetland attributes and waterbird species. Studies suggested that the key influences on waterbird species richness in wetlands are wetland area, the diversity of vegetation types within wetlands, and the characteristics of surrounding landscape. Together, the collection of individual species accounts as well as the community level assessment serves as a repository of scientific knowledge on the habitat needs of Lake Ontario/St. Lawrence River waterbirds. As such, the report can be used by various members of the Environmental Technical Working Group for identifying key wetland parameters that should be included in wetland-waterbird habitat models. The synthesis of the waterbird literature has been used as originally intended by many members of the IJC Environmental and Technical Working Group to design field surveys and develop appropriate modeling approaches to assess the effects of different water management schemes on wetland wildlife in the Lake Ontario region. The report has also been adopted by the waterbird conservation community as a useful synopsis of an extensive literature on waterbird-habitat relationships.

Another part of this study examined the effects of water levels on breeding terns on the St. Lawrence River. Studies show that lake and river water levels affect the availability of habitat and the breeding productivity of shoreline nesting gulls and terns. Factors that influence water levels and shoreline nesting birds include the water level at Kingston (i.e. Lake Ontario level), plan flow discharge, peaking operations by power entities, and wind effects. Combined, these factors can and do affect the distribution and nest success of breeding gulls and terns at some individual nesting colonies on eastern Lake Ontario and the St. Lawrence River. This study created a GIS database of colonial waterbird colonies on eastern Lake Ontario and the St. Lawrence River and a model estimating the incidence of colony flooding for given water levels.

The concepts and techniques of ecologically sustainable water management (ESWM) were introduced to the Environment Technical Working Group (ETWG) through an experts' workshop organized in May 2002, and through the application of the Indicators of Hydrologic Alteration (IHA), a statistical tool that compares the pre- and post-management values of 32 biologically significant hydrologic variables for assisting in the interpretation of the hydrologic analysis. This corresponds to the goal to ensure that the biodiversity of the Lake Ontario/St. Lawrence River ecosystem is fully considered in the development of new criteria for the regulation of water flows in the St. Lawrence River.

The workshop, which was attended by five ETWG principal investigators and several other biologists and ETWG members, identified 11 hydrologic variables of greatest importance to the survival of keystone species like the muskrat, and to the quality and quantity of shoreline natural communities.

Workshop participants also specified relationships between these variables and biological indicators, and these hypothesized relationships were clarified by in-depth interviews with scientists following the workshop. Results of this analysis and discussion were summarized in a spreadsheet and distributed to ETWG investigators for comment.

The third workshop goal -- quantifying the relationships between hydrology and biological indicators -- a statistical comparison will be done of the unregulated and regulated scenarios for the upper River and Lake from data provided by a simulation model developed by David Fay. These scenarios control for the effects of upstream modifications and changing water supplies during the period of record.

This statistical comparison will be combined with analysis of IHA results to isolate the impacts of regulation on the significant hydrologic variables. Further in-depth consultation with scientists will form the basis for a final report and revised spreadsheet that summarize the impacts of regulation and the biologists' current interpretation of the significance of these impacts to the biota of the Lake and River.

An investigation into the mechanisms controlling storm water quality improvement by a large, stream-outflow wetland draining into Irondequoit Bay, Lake Ontario, New York

Basic Information

Title:	An investigation into the mechanisms controlling storm water quality improvement by a large, stream-outflow wetland draining into Irondequoit Bay, Lake Ontario, New York
Project Number:	2001NY1142B
Start Date:	3/1/2001
End Date:	8/31/2002
Funding Source:	104B
Congressional District:	26
Research Category:	Water Quality
Focus Category:	Wetlands, Water Quality, Surface Water
Descriptors:	Irondequoit Creek, stormwater treatment, streams, water quality, wetlands
Principal Investigators:	Rebecca L. Schneider

Publication

1. R. Schneider; Coon, W.; Pierson, O.; and Walter, M. T., 2003, Evapotranspiration - groundwater interactions in a large cattail wetland, Society of Wetland Scientists Annual Conference, New Orleans, Louisiana, June 2003.
2. R. Schneider; Coon, W.; Pierson, O.; and Walter, M. T., 2003, (Invited Plenary Speaker) Evapotranspiration - groundwater interactions in a large cattail wetland, Geological Society of America, Seattle, Washington, November, 2003.

Problem & Research Objectives:

Wetlands are now acknowledged, and utilized, as a natural, powerful mechanism for reducing NPS because of their ability to filter out sediments, trace metals, and nutrients from storm water runoff before these contaminants can enter streams and lakes. New York is unusual in having five or more large, 100+ acre, wetlands strategically located along the mouths of rivers and lakes and cumulatively draining more than one thousand square kilometers of watersheds of the Finger Lakes and Lake Ontario. Relatively little is actually known about how any large wetlands, greater than 30 ha, interact with stream surface waters to reduce contaminants. It is uncertain whether sedimentation, groundwater dilution, wetland transformation, or some other process is responsible for the improvements in water quality. Do these processes change seasonally, among years, or as regional hydrologic conditions become more extreme? Can their wetland functions be impaired with chronic or pulse loading of contaminants?

In a previous study, we looked at seasonal patterns in wetland-stream interactions by monitoring a network of two stream gauges and seven stations, each consisting of a water table well, two nested piezometers, and floating boardwalks, all established in June, 1999 within a 4 ha subsection of a 200 ha cattail wetland on Irondequoit Bay, New York. This work suggested that the stream-wetland interactions are not constant through time, but instead shift through four distinct phases as climatic /hydrologic conditions shift from drought to flooding (M.S. Thesis, Traynor 2002). The research conducted under the current grant has concentrated on a shorter time scale, and examined how daily factors identified in the first study, including cattail plant evapotranspiration, precipitation events, and over-bank flood events, are affecting wetland filtering processes. The specific objectives for the this project were: (a) to develop, test, and monitor a unique, in-situ lysimeter for measuring whole plant evaporation from the cattails directly in the field, (b) to monitor cattail health both within the lysimeters and in quadrats outside the lysimeters, in order to document plant phonological changes, to verify that the lysimeters were working properly, and to quantify total leaf surface area available for transpiration, and (c) to monitor and relate water table elevation and hydraulic head gradients with the ET measurements. This work was conducted in parallel with a complementary study examining how phosphorus retention by the wetland is affected by the same hydrologic processes. The broader goal will be to investigate these short-term hydrologic and biogeochemical processes and then place them in the context of the documented seasonal and interannual patterns for an overall understanding of how the Irondequoit Creek wetland functions in surface water quality improvement.

Methodology:

Eight in situ lysimeters were implanted directly within the substrate along a transect within the wetland study site in late August, 2001. The transect extended perpendicular from the steam edge 200 m into the cattail marsh and intercepted a near-stream well station, an interior-marsh well station, as well as a stream gauge. Each lysimeter consisted of a plastic tub (50 cm diameter by 54 cm height) with an observation well (approx. 10 cm diameter) attached to the inside wall. A 30 cm plug of cattails was implanted in the tub within a matrix of the peaty soil removed to

create the hole for the tub. All lysimeters were installed in August, 2001 and allowed to grow undisturbed through the fall and following early spring.

At the time of each ET measurement, water table level within the lysimeter was brought up to a designated line within the observation well and then the cattails were allowed to transpire for 2-3 days undisturbed. At the end of the measurement period, the amount of water lost by each lysimeter was determined by refilling back to the line using a graduated cylinder. In between ET measurements, the lysimeters were reopened to allow the free flow of groundwater needed to sustain the plants.

Water table levels and piezometric head gradients were monitored once weekly at all of the seven stations throughout the marsh. In addition, an automated water level recorder was installed and monitored by USGS personnel at one stream gauge, and at both the near-stream and interior-marsh water table wells located along the transect. Water table levels were monitored continuously from May through November, 2002.

Cattail health was monitored within each lysimeter and in a 0.5 m^2 quadrat adjacent to each lysimeter on ten different dates from June through October, 2002. For each measurement, the number of stalks, number of leaves and height of each leaf was recorded.

Phosphorus retention processes by the wetland were determined over this same period. A mass balance approach was used to compare near-stream and interior wetland sites. All sampling was conducted in three replicated quadrats located in associated with the three near-stream and three interior groundwater monitoring stations. Methods included periodic sampling of aboveground live cattail biomass, standing dead biomass, litter, belowground biomass, soil phosphorus, and porewater phosphorus. Sediment deposition during overbank flood events was determined using sediment and litter traps. Samples were dried, ground, digested, and phosphorus determined using spectrophotometric techniques. Details of the methodology and results will be available in O. Pierson's Master's thesis later this fall, 2003.

Principal Findings and Significance:

The unique, replicated, in situ lysimeters were very successful and provide a new, previously unreported, technique for measuring whole plant evapotranspiration continuously in wetlands. The integrated approach of monitoring plant evapotranspiration and groundwater also provides new and powerful insights into wetland hydrologic and biogeochemical filtering functions in really large wetlands.

Eleven ET measurements were made over the six month study period. The average ET rate ranged from two to five l-m^2-day (or mm), was slightly above Potential ET as estimated by Northeast Regional Climate Center, and varied over time with weather and plant phenology. Overall, the marsh is extremely productive, with a peak cattail biomass of more than 2000 g (oven-dried weight) and average plant heights of 2.5 m to 3.0 meters. Plants growing in the lysimeters were similar in heights, stem numbers, and leaf surface area to plants growing outside

the lysimeters, with some minor differences. There was a peak in ET in June, prior to the peak in plant biomass, and then a decrease in September with plant senescence.

Evapotranspiration was found to interact with groundwater processes at three different scales in the marsh. At the smallest scale, e.g. one m^2, daily ET caused a diurnal drawdown in the water table elevation directly within the root zone of 3-7 cm, with a only a partial night-time recovery. However this diurnal influence was not uniform throughout the marsh. Diurnal drawdown was strongest in the near-stream site but non-detectable in the interior-marsh sites. This difference was due in part to a difference in hydraulic conductivity of the substrates at the two sites, as estimated using slug tests in the associated wells. Water moved more rapidly through the interior-marsh soil, replacing ET withdrawals and preventing a drawdown. As a result of the steady decline in the water table at the near-stream site, a 30 cm difference in water table height developed between the near stream and interior sites by August, which created a shallow mound and depression water table surface across the 4 ha study site. This mounding influenced the direction and lengths of shallow groundwater flow paths through the marsh. Finally, ET acted cumulatively throughout the entire 200 ha wetland to create a loss of pure water from the groundwater of several million liters of water each day, depending on weather and season.

These interactions of ET with groundwater are expected to influence biogeochemical processes at three different scales as well. At the smallest scale, diurnal drawdowns should affect redox conditions within the root zone. Regular diurnal shifts from oxic to anoxic conditions within the root zone should result in a change in availability of phosphorus, iron and other redox-sensitive trace metals, and influence pH conditions and pH- sensitive nutrients as well. At the 1000 m^2 scale, the mound and depression formation resulting from the ET influences will affect sources of groundwater and the length of flowpaths over which filtering can occur. Preliminary results from the companion phosphorus study indicate that there are significant differences in phosphorus mass balances between the near-stream and interior- marsh sites. Overall phosphorus budgets, phosphorus storage in plant tissue, and soil phosphorus are greater in the near-stream than the interior-marsh sites. We are evaluating the relative contributions of ET, sediment deposition, and substrate differences for their contribution to phosphorus retention. However, these preliminary findings suggest that the majority of phosphorus retention in the larger, 200 ha wetland is concentrated in near-stream habitats. Finally at the largest scale, the considerable withdrawal of fresh water from the groundwater system during the growing season will affect the overall hydrologic budget for the marsh. We are working with a groundwater modeling package, MODFLOW to determine how the affects of ET on the groundwater system might influence the chemistry of the water leaving the wetland.

This study has been successful in providing a new method for monitoring whole plant, in situ ET rates and for increasing our understanding of the hydrologic-biogeochemical filtering processes in really large wetlands. It has demonstrated that ET is a significant process in wetlands that will influence groundwater at three different spatial scales. In particular, ET-substrate interactions differ across the spatial scale of this large marsh and may be responsible for the differences in phosphorus retention between near-stream and interior-marsh sites. This finding has important implications for understanding and managing large wetlands for phosphorus retention.

An interactive, Internet-based, nonpoint source pollution modeling system for improving landscape management

Basic Information

Title:	An interactive, Internet-based, nonpoint source pollution modeling system for improving landscape management
Project Number:	2001NY1561B
Start Date:	3/1/2001
End Date:	8/31/2002
Funding Source:	104B
Congressional District:	26
Research Category:	Social Sciences
Focus Category:	Management and Planning, Models, Surface Water
Descriptors:	water quality models, internet, streams, water quality management, nonpoint pollution
Principal Investigators:	Rebecca L. Schneider, Marcia Meixler

Publication

Problem & Research Objectives:

In deciding how to improve water quality in a watershed, managers should be asking questions such as: What are the most effective Best Management Practices (BMPs) for improving water quality in a given region? How would current water quality conditions change with an adjustment in land use? How much change would implementation of a BMP create in pollutant runoff, such as total phosphorus or suspended solids? Frequently, however, the information needed to answer such questions is embedded in highly technical reports of model-based studies, and therefore largely unavailable to untrained audiences. This proposal addresses the creation of a tool for use on the Internet by both planners and community members to understand the processes relating land use management to water quality. This educational tool will enable watershed management agencies to visualize the use of several different BMPs in landscape management and will help community members gain a better understanding of their watershed.

The research objective is to modify an existing model to create a simple-to-use, landscape planning education tool that will facilitate stakeholder involvement and consensus building in watershed management. This project would build upon a previously created watershed simulation model. Data will be available from on-going work in the Cattaraugus and Irondequoit watersheds in NY. The proposed interactive, Internet-based tool allows users to apply landscape changes and view model results for impacts to several different water quality parameters.

Methodology:

This project involved literature review, data collection, water quality model enhancement and testing, and web site development. We compiled digital data layers for land use, soils, rainfall, elevation, stream segments and drainage basins for the New York tributaries to the Great Lakes, and specifically for the two target watersheds. Comparable data layers provided the basis for the surface water nonpoint source, GIS-based, pollution screening model, initially developed by Adamus and Bergman (1995). Their model calculates the volume of runoff using runoff coefficients for land use and soil categories and predicts sediment and pollutant loading using known concentrations given each land use type. We have been developing a slightly modified model which further takes into account the factors of local topographic slope and position of wetlands relative to the stream in order to predict loading of total phosphorus, lead, zinc and suspended solids to each stream segment.

Principal Findings & Significance:

Patterns of land use have a direct linkage to downstream water quantity and quality because they act as sources of contaminants, influence the degree of filtering of these contaminants, and influence the magnitude of runoff which transports the contaminants to the receiving water body. However, often town planners, highway departments, and other local government officials may not be aware of these connections or the influence of land use planning decisions on water resources. Through this project, we have been developing an Internet-based education tool that will be readily available and easy to use by local government officials, as well as public schools and other interested stakeholders. A simple model has been developed that integrates information

from 1994 remote imagery-based land use maps, soils maps, and digital elevation models for two target watersheds in western New York. Using this model, we have developed rough estimates of the loadings of total phosphorus, suspended sediment, and trace metals that result from six different land use scenarios. The Internet user will be able to select among two watersheds differing in the amount of urban development and six different land use scenarios in each of the watersheds to understand the effect of either changing land use or adding various best management practices. Specifically, the six scenarios are: (1) current land use conditions (as of 1994), (2) pre-human development as a reference condition, (3) addition of streamside buffers throughout each watershed to reduce water contamination, (4) addition of constructed wetlands for controlling stormwater runoff, (5) improvement of soil management practices in agricultural areas, and (6) increasing development for its degrading impacts on water quality. As of September 2002, the model and its outputs were largely completed. The final step is to translate the model results into a Web-based format with appropriate accompanying text. However, this final step has been delayed due to some problems encountered with the accuracy of some of the model predictions and with difficulty in translating the large size of the model maps into a easily accessible Web-format. As a result, final availability of the Internet-based product has been delayed until summer, 2003.

Modeling phosphorus control best management practices on a watershed scale to improve surface drinking water quality

Basic Information

Title:	Modeling phosphorus control best management practices on a watershed scale to improve surface drinking water quality
Project Number:	2001NY921G
Start Date:	9/1/2001
End Date:	8/31/2004
Funding Source:	104G
Congressional District:	26
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Agriculture, Water Quality
Descriptors:	dissolved phosphorus, water quality modeling, best management practices, watershed management, hydrology
Principal Investigators:	Tammo Steenhuis

Publication

1. Gérard-Marchant, P.;T. S. Steenhuis; M. T Walter; V. T. Mehta; M. S. Johnson; and S. Lyon, 2002. Saturated Excess Runoff Modeling in Undulating and Mountainous Watersheds, Poster EGS02-A-00665, EGS XXVII General Assembly, Nice, France, April 2002.
2. Gérard-Marchant, P., 2002, The Soil Moisture Routing Model: A User Manual, Version 1.0, Soil and Water Laboratory, Biological and Environmental Engineering Dept., Cornell University, Ithaca, NY, USA.
3. Johnson, M.S., 2001, Comparative Analysis of Two Watershed Hydrologic Models for a Central New York State Watershed: Hydrological Simulation Program - Fortran (HPSF) and the Soil Moisture Routing Model (SMR), MS Thesis, Cornell University, Ithaca, NY, USA.
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6. Walter, M. T.; T. S. Steenhuis; V. K. Mehta; D. Thongs; M. Zion; and E. Schneiderman, 2002, Refined Conceptualization of TOPMODEL for Shallow Subsurface Flows, Hydrological Processes,

16:2041-2046.
7. Walter, M. T.; V. K. Mehta; A. M. Marrone; J. Boll; T. S. Steenhuis; and M. F. Walter, 2002, A Simple Estimation of the Prevalence of Hortonian Flow in the New York City Watersheds, ASCE J. Hydrol. Engr. In press.
8. Mehta, V. K.; M. T. Walter; E. S. Brooks; T. S. Steenhuis; M. F. Walter; M. Johnson; J. Boll; and D. Thongs, 2002, Application of SMR to Modeling Watersheds in the Catskill Mountains. Env. Modeling and Assessment. In press.

Problem & Research Objectives:

Non-point sources -- agriculture is no exception -- are one of the largest contributions of phosphorus (P) to surface waters, where excess P typically results in eutrophication. The Environmental Protection Agency (EPA) generally requires filtration for surface water supplies. New York City (NYC) was granted an exemption from filtration for surface drinking water supplies provided that an acceptable watershed program plan and protective measures can be achieved, with significant emphasis on P control. A high priority has been placed on the development and implementation of effective best management practices (BMPs) for P control. However, no effective modeling tool is available to evaluate the potential impacts of BMPs on P transport in shallow, sloping soils such as occurring in the northeastern US.

The overall goal of this study is to develop and test a model that can predict, on the watershed scale, the transport of P from agricultural and forest lands on shallow sloping soils. This will be accomplished by: 1) performing laboratory and field experiments to understand P movement on shallow soils, 2) improving the spatially distributed Soil Moisture and Distribution model (SMDR) that includes P fate and routing routines, and 3) validating the model with data collected from Town Brook and other watersheds in the Catskills.

Methodology:

In order to understand P movement on shallow soils, we decided to put more emphasis on P loss from manure and fertilizers than was originally described in the proposal. A set of experiments have been carried out the field with milk house wastewater strips. The advantage of these strips is that daily P is added and, therefore, ideal to study the movement of P. A set of experiments on artificial runoff plots in the laboratory with a rainulator experiments have been carried out but the results have not been analyzed yet.

Phosphorus losses are highly dependent on the distance to streams. Therefore, P transport should be simulated with a model that conserves the spatial information. Spatially distributed models are ideal for this purpose. For this project, we will adapt the spatially distributed SMDR model by incorporating P generation and transport mechanisms (SMDR has been proven suitable for the hydrologic and geologic characteristics of the Northeast).

Validation will occur in two steps. First, the simple analytical relationships between soil P content and P concentration in surface and groundwater will be validated with simple laboratory experiments described above. Then, the SMDR model with the laboratory validated P routines will be tested on a watershed scale.

Principal Findings & Significance:

The project was funded in November 2001 and, consequently, the principal findings relate to the first one and a half-year of the study.

The field laboratory studies with the milk house wastewater filter have been completed and showed that dissolved P can move over the same distance as a chloride tracer. The data have been analyzed and are currently written up. One publication has been submitted and two more are nearly finished.

During the first year of the project we prepared two publications concerning the validation of the previous version of SMDR (called Soil Moisture Routing Model or SMR). The paper by Metha et al. (2003) is now in press. We also compared the model with the Hydrological Simulation Program -- Fortran (HSPF). Discharges were simulated equally well with both models, but only SMR was able to accurately predict the spatial distribution of water and locations of runoff-generating zones in the watershed. This paper was returned for revisions to us.

The new SMDR code is now stabilized and is being rewritten in C so that it can be executed as part of the ARC. In this new code, infiltration and drainage are simulated more realistically. This was necessary in order to implement routines for P leaching in the soil. Evaporation calculation algorithms were also modified to take better into account the development stages of different vegetation covers. Additional routines were developed to simplify the generic use of the program and to streamline the importation of input maps or the creation of input look-up tables. A user manual, incorporating a fully commented code, has been released.

We also showed that TOPMODEL could be used on shallow soils without a ground water table by simply transforming the depth of the groundwater to moisture content in the soil above the impermeable layer. More details are given in Walter *et al.* (2002).

In addition, a simple model has been developed for the release of P from spread manure. This model links cumulative P load released to cumulative runoff, through a simple relationship requiring the knowledge of only two parameters: percentage of water-extractable P in the manure and the volume required to wash half the P out of the manure. This paper has been submitted for publication.

Finally, we have developed a routine that allows us to calculate the loss of land-applied manure. A fully distributed modeling of manure P leaching requires the knowledge of the actual location of the land-applied manure, as well as the quantities involved. Unfortunately, such data is not available. Therefore, a semi-distributed approach is followed. The watershed is divided in a number of geographical units. Each unit corresponds to the smallest area for which some information about manure application is available: for example, a farm, or a particular field in a farm, depending on the scale of the watershed. Each of these "manure application units" is then subdivided into elementary "spreading plots". The size of each plot is defined as the area covered during a single manure spreading. For example, when manure application units are identified with fields, the plot size will correspond to the area covered by a single spreader, that is, a stripe of approximately 2000 m^2 (723 x 33 with a 4overlap). This model has been tested on a farm in the Catskill Mountains and gave reasonable results. This paper will be presented at the international AWRA meeting in New York City this summer

Notable Achievements:

We have been able to modify the SCS curve number approach so that it can be used with the topographic index to predict the saturated areas in undulating landscapes with relatively shallow soils.

A Watershed-Scale Biogeochemical Loading Model for Nitrogen and Phosphorus

Basic Information

Title:	A Watershed-Scale Biogeochemical Loading Model for Nitrogen and Phosphorus
Project Number:	2000NY5G
Start Date:	9/1/2000
End Date:	8/31/2003
Funding Source:	104G
Congressional District:	NY26
Research Category:	Water Quality
Focus Category:	Hydrology, Models, Nutrients
Descriptors:	denitrification, ecosystems, hydrologic models, geographic information systems, land-water interactions, land use, mathematical models, rainfall-runoff processes, watershed management
Principal Investigators:	Robert W Howarth, Elizabeth W. Boyer, Dennis Swaney

Publication

1. Alexander, R. B.; P. J. Johnes, E. W. Boyer; and R. A. Smith, 2002, A comparison of methods for estimating the riverine export of nitrogen from large watersheds, Biogeochemistry 57:295-339.
2. Boyer, E. W.; C. L. Goodale; N. A. Jaworski; and R. W. Howarth, 2002, Anthropogenic nitrogen sources and relationships to riverine nitrogen export in the northeastern USA, Biogeochemistry 57:137-169.
3. Howarth, R. W.; E. W. Boyer; W. Pabich; and J. N. Galloway, 2002), Nitrogen flux in the United States from 1961 - 2000 and potential future trends, Ambio, 31(2):88-96.
4. Howarth, R. W.; R. Marino; D. P. Swaney; and E. W. Boyer, 2002, Wastewater and watershed influences on primary productivity and oxygen dynamics in the lower Hudson River Estuary, In: J. Levinton (editor), The Hudson River. Academic Press, NY. In press.
5. Howarth, R. W.; D. Walker; and A. Sharpley, 2002, Sources of nutrient pollution to coastal waters in the United States: Implications for achieving coastal water quality goals, Estuaries 25(4B):656-676.
6. Scavia, D. J.; C. Field; D. Boesch; R. Buddemeier; V. Burkett; D. Canyan; M. Fogarty; M. A. Harwell; R. W. Howarth; C. Mason; D. J. Reed; T. C. Royer; A. H. Sallenger; J. G. Titus, 2002, Climate change impacts on US Coastal and marine ecosystems, Estuaries 25(2):149-164.

7. Seitzinger, S. P.; R. V. Styles; E. W. Boyer; R. Alexander; G. Billen; R. W. Howarth; B. Mayer; and N van Breemen, 2002, Nitrogen retention in rivers: model development and application to watersheds in the northeastern US, Biogeochemistry 57:199-237.
8. Van Breemen, N.; E. W. Boyer; C. L. Goodale; N. A. Jaworski; S. Seitzinger; K. Paustian; L. Hetling; K. Lajtha; M. Eve; B. Mayer; D. van Dam; R. W. Howarth; K. J. Nadelhoffer; and G. Billen, 2002, Nitrogen budgets for 16 watersheds draining to the northeastern US coast: storage and losses of nitrogen inputs, Biogeochemistry 57:267-293.
9. Mayer, B.; N. Jaworski; E. Boyer; R. Howarth; C. Goodale; L. Hetling; S. Seitzinger; G. Billen; R. Alexander; N. van Breemen; K. Paustian; D. van Dam; K. Lajtha; and K. Nadelhoffer, 2002, On the feasibility of using the nitrogen and oxygen isotope ratios of nitrate for describing the origin of riverine nitrate and N transformations in large watersheds, Biogeochemistry 57:171-197.
10. Smith, S. V. ; D. P. Swaney; L. Talue-McManus; J. D. Bartley; P. T. Sandhei; C. McLaughlin; V. C. Dupra; C. J. Crossland; R. W. Buddemeier; B. A. Maxwell; and F. Wulff, 2003, Humans, Hydrology, and the Distribution of Inorganic Nutrient Loading to the Ocean, Bioscience 53(3):235-245.

Problem & Research Objectives:

Two recent reports from the National Academy of Sciences have concluded that eutrophication is the biggest pollution problem in the coastal marine waters of the United States (NRC 1993, NRC 2000). Eutrophication lowers biotic diversity, leads to hypoxic and anoxic conditions, facilitates harmful algal blooms, causes dieback of seagrass beds, and can lead to changes in ecological food webs that lower fishery production (NRC 2000). Over 40% of the estuaries in the country are degraded from eutrophication, with the problem being particularly severe in the northeastern and mid-Atlantic regions (Bricker 1999). For most estuaries in these regions, eutrophication is caused primarily from over-enrichment with nitrogen; phosphorous is a secondary contributor (e.g., Nixon 1995; NRC 2000). Most nitrogen delivered to coastal waters in the US comes from non-point sources in the landscape, with agricultural sources, human waste, and atmospheric deposition being major contributors (e.g., Howarth *et al.* 1996; Smith *et al.* 1997; Goolsby *et al.* 1999; Boyer *et al.* 2002).

In regions subject to changes in land use and to atmospheric deposition of nitrogen, the processes that control nutrient loads to the coastal zone are complex. Variability of these hydrological and biogeochemical processes is increasing as weather and climate change. Understanding how these processes affect the magnitude and transformations of the nutrient loads is necessary in order to manage the environmental resources of the coastal zone. Further, it is important for those living in and managing coastal watersheds to understand the impacts of their activities and policies on these nutrient loads. A relatively simple modeling tool that can estimate the impacts of various activities in the watersheds can greatly enhance, at low cost, our ability to manage these regions effectively and to communicate the effects of human activities and environmental processes on nutrient loads. The report of the National Academy of Sciences Committee on Causes and Management of Coastal Eutrophication concluded that no model currently available to managers fulfills this need. Our objectives are to develop such a model, targeted toward management applications.

Our model will characterize biogeochemical reactions that occur as water moves through the watershed (e.g., from an upland hillslope through the riparian zone to the river). Our goal is to create a model structure that will be used widely; thus we are developing it in spreadsheet software (Excel); and will provide documentation on how to make use of spatial data to calculate model input parameters and to visualize spatial elements of the model output using GIS software (Arc View). Both Excel and Arc/View can be run on PC or Macintosh platforms, and are among the most popular software of their types.

Methodology:

Our model combines the event-based dynamics of a simple, lumped hydrologic model (Generalized Watershed Loading Function Model, or GWLF; Haith and Shoemaker 1987) with biogeochemical dynamics suggested by statistical analyses of spatially-referenced data (the Spatially Referenced Regressions On Watershed Attributes Model, or SPARROW; Smith et al.1997) and with information derived from spatially referenced data using GIS. GWLF is a parsimonious, event-based model that has been used successfully to analyze the hydrology,

sediment, and nutrient loads of many mixed watersheds in the United States, including watersheds flowing into the Hudson, Tar-Pamlico, and Chesapeake Bay estuaries (e.g., Swaney *et al.* 1996, Lee *et al.*, 2000). The original model used daily historic or synthetic temperature and precipitation data to simulate monthly discharge, sediment load, and nutrient transport. We used this simple model as a starting point, and are in the process of modifying it to capture the features of landscape and hydrological processes which control nutrient retention and transport. To date, we have arrived at a "defining equation" which will be the basis of our modified model to quantify nutrient loadings to the coastal zone. This equation, parameterized statistically, incorporates some critical ideas about sources of nutrients to the landscape and on transport and transformation processes that affect the delivery of nutrients from landscapes to the coastal zone. We consider two types of sources of nutrients, diffuse (nonpoint), for which integrated effects of landscape processes control much of the transport and attenuation, and point sources, which are attenuated by in-stream processes. In particular, we represent inputs to each watershed of interest from atmospheric deposition, fertilizer use, nitrogen fixation in cultivated crop lands, animal waste, and human waste.

Hydrological, meteorological, and nutrient load data are necessary to calibrate and validate the model. We have assembled detailed data hydrological processes, nutrient inputs, and nutrient loadings in a variety of catchments, which are available for parameterizing the model and for assessing model predictions. These include data from the USGS Hudson River NAWQA program (via co-investigator Phillips), the USGS HBN and NASQAN programs (via co-investigator Alexander), the SCOPE Nitrogen project data on large coastal catchments in the northeastern USA (via co-investigators Boyer and Howarth), and for the Mississippi River system (via colleague Don Goolsby).

Principal Findings & Significance:

The model that we are developing will allow us to understand how inputs of nutrients to the landscape are attenuated by hydrological and biogeochemical transport and transformation processes, and to predict nutrient loadings to coastal and inland ecosystems. Once the model is fully developed and evaluated, we will use it to investigate effects of environmental, land use, and land management changes on both sources of nutrients to the landscape and the resulting loadings of nutrients to the coastal zone. For example, we will consider the potential effects of changing atmospheric emissions via regulations, implementing various types of sewage treatment, implementing best management practices for agricultural, urban, and forest lands, and more. We are using this tool in our own research to examine the joint effect of climate and land use change on biogeochemical processes and nutrient dynamics within 16 NE US watersheds, including the Hudson, and comparing the results to previous studies (Boyer *et al.*, 2000). Finally, through the cooperation of the extension/outreach component of the Cornell Watersheds Program of the Center for the Environment, our modeling tools and results will be available for use by watershed and coastal zone managers, via the the project website. The website, http://www.cfe.cornell.edu/biogeo/USGSWRI.htm, is the repository for all project materials, including data, instructions, models, and results, and is hosted by Cornell University's Center for the Environment. We expect to continue to revise and add materials to the webpage through the end of 2003, including example datasets and the latest model updates. Our work will provide

land managers with information relevant to mitigating nutrient pollution problems in coastal and inland waters.

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National Research Council (NRC). 1993. Managing Wastewater in Coastal Urban Areas. National Academy Press, Washington, DC.

National Research Council (NRC). 2000. Clean Coastal Waters: Understanding and Reducing the Effects of Nutrient Pollution. National Academy Press, Washington, DC.

Nixon, S. W. 1995. Coastal marine eutrophication: a definition, social causes, and future concerns. *Ophelia* 41: 199-219.

Smith, R.A., G. E. Schwarz, R. B. Alexander. 1997. Regional interpretation of water quality monitoring data. *Water Resources Research 33,* 2781-2798.

Swaney, D. P., D. Sherman, and R. W. Howarth. 1996. Modeling water, sediment, and organic carbon discharges in the Hudson-Mohawk Basin: coupling to terrestrial sources. *Estuaries* 19: 833-847.

Notable Achievements:

Initial development of project website, http://www.cfe.cornell.edu/biogeo/USGSWRI.htm
Completion of alpha version of Excel-based GWLF.

Invited talk on the history of land use change in the Hudson watershed (Swaney & Howarth) at the annual meeting of the Hudson River Environmental Society, March, 2003.

Information Transfer Program

Greenhouse BMPs: Transforming Principles into Practice Year Two

Basic Information

Title:	Greenhouse BMPs: Transforming Principles into Practice Year Two
Project Number:	2002NY8B
Start Date:	3/1/2002
End Date:	2/28/2003
Funding Source:	104B
Congressional District:	NY 26
Research Category:	None
Focus Category:	Agriculture, Non Point Pollution, None
Descriptors:	None
Principal Investigators:	Jana Lamboy, Thomas Weiler, Mary-Lynn Cummings

Publication

1. Koplinka-Loehr, C.; J. S. Lamboy; M. L. Cummings. 2002. Brochure: Protecting Your Business and the Environment with Best Management Practices. New York State Integrated Pest Management Program.
2. Lamboy, J. S.; T. C. Weiler; and M. L. Cummings, 2002, Protecting the Environment with Best Management Practices, 11"x17" Poster, NYS Integrated Pest Management Program, Cornell University, Geneva, NY.
3. Weiler, T.C., 2002, Best Management Practices for Watershed Protection: Greenhouse Fertilizers, Fact sheet, NYS Integrated Pest Management Program, Cornell University, Geneva, NY.

Problem & Information Transfer Objectives:

The 2001 Directory of New York State Certified Nurseries, Greenhouses, and Plant Dealers lists 1,967 operations. Many of these businesses discharge wastewater directly to the ground surface or through drains to surface water. Greenhouse and nursery wastewaters are likely to contain some contamination from the legal and appropriate use of pesticides and fertilizers. New York growers need simple and direct resources explaining how to construct safe storage facilities for pesticides, and why and how they should monitor their nutrient solutions.

The goal of this project is to increase awareness and implementation of best management practices for minimizing the discharge of nutrient- and pesticide-contaminated wastewaters from commercial greenhouses and nurseries in New York State. The target audience includes commercial greenhouse owner/operators, extension educators, and horticultural students. The project will satisfy three primary objectives:

- Develop an Agricultural Environmental Management (AEM) program for commercial greenhouses.
- Teach horticulture students and CCE educators how to evaluate current practices.
- Reach industry leaders to enlist their support to increase adoption of BMP principles.

Methodology:

The current Cornell Research Greenhouse BMP Plan addresses several areas of greenhouse environmental stewardship in depth but it was not written for commercial establishments. In 2001 we learned about grower concerns and prepared introductory materials for the industry. We are ready to revise the BMP Plan within the framework of AEM.

Principal Findings & Significance:

With input received from growers and Agricultural Environmental Management (AEM), we revised the Cornell Best Management Plan for Research Greenhouses to be better suited for commercial operations. This involved expanding the current status descriptions in each worksheet from three categories to four, writing the relevant water quality principles, and creating the glossary. The fertilizer and pesticide storage sections were separated to clarify the different issues related to the chemicals. The seven worksheets are currently being reviewed by AEM: Nutrient Storage in the Greenhouse, Nutrient Usage in the Greenhouse, Pesticide Storage in the Greenhouse, Weed Management for the Greenhouse, Pest Management for the Greenhouse, Greenhouse Maintenance, and Greenhouse Construction.

Notable Achievements:

Educational resources have been developed and distributed to greenhouse operators and Extension Educators in New York. Several presentations noting environmental and worker safety concerns and the benefits of BMPs have been made at industry meetings. A few industry leaders have requested further information and have held awareness workshops with their employees. In a few cases, back-flow-prevention devices have been installed to protect water sources from movement of in-line fertilizers back to wells or municipal supplies because of pressure failure.

Extension Educators and key nurserymen on Long Island have asked for our participation in creating materials for container nurseries. The Friends of Long Island Horticulture will fund the next project with a grant to Jana Lamboy and Scott Clark, Suffolk County CCE.

Director’s Office Information Transfer

Basic Information

Title:	Director’s Office Information Transfer
Project Number:	2002NY9B
Start Date:	3/1/2002
End Date:	2/28/2003
Funding Source:	104B
Congressional District:	NY 26
Research Category:	Not Applicable
Focus Category:	Management and Planning, None, None
Descriptors:	information transfer, education, water quality management, hydrology, stormwater
Principal Investigators:	Keith S. Porter

Publication

1. Chan, Jason; Jonathan Lapsley; and Michael Sorensen, 2003, Hydrologic Study in the Southern Hudson River Basin: An HSPF Simulation Model for the Rondout Watershed, Master of Engineering Design Project Report, Cornell University, School of Civil and Environmental Engineering, Ithaca, NY, 103pp.

Over the past year WRI has continued to promote specifically the engagement of the wider academic community in water resource management issues in New York State. As in previous years, opportunities to pursue this aim were sought through the New York State Soil and Water Conservation Committee, the New York State Agricultural Environmental Management Committee, and the New York State Non Point Source Management Coordinating Committee (NPSCC). NYS WRI also participates in work groups of NPSCC, with an emphasis on stormwater (the highest priority for NPSCC leader NYS Department of Environmental Conservation), agriculture, and information and outreach. Most NYS WRI activity on these groups in FY2002 related to Delaware County phosphorus management projects, drawing in local government partners from that cluster.

As part of the Delaware County project cluster, Landscape Architecture student Outi Salminen worked with the Village of Stamford and an engineering consultant to devise options for stormwater quality management, flood management, and recreation. The project revolves around a piped stream channel downstream of a wetland that formerly hosted a small impoundment. Restoration of the impoundment and opening up of much of the currently piped stream could improve wildlife habitat, eliminate local flooding, and possibly benefit water quality.

Master of Engineering students Michael Sorensen, Jonathan Lapsley, and Jason Chan modeled the water budget of the Rondout Creek/Wallkill River subbasin of the Hudson River basin. Their application of simulation model HSPF (using EPA's BASINS framework) pilots the possible modeling of the entire lower Hudson basin for climate change and land development impact assessment.

Cayuga Lake Watershed Education Program Web-linked Interactive CD-ROM

Basic Information

Title:	Cayuga Lake Watershed Education Program Web-linked Interactive CD-ROM
Project Number:	2001NY1881B
Start Date:	3/1/2001
End Date:	2/28/2003
Funding Source:	104B
Congressional District:	26
Research Category:	Water Quality
Focus Category:	Water Quality, Education, None
Descriptors:	Education, Cayuga Lake, Computer-based training,Water quality modeling
Principal Investigators:	Daniel P. Loucks, Linda P. Wagenet

Publication

1. Anderson, S.; and J. Lozano, 2003, Cayuga Lake Watershed Educational Program Web-linked interactive CD, NYWEA Spring Technical Conference, June 4-6, 2003, Saratoga Springs, NY.

Problem & Information Transfer Objectives:

The objective of this project is to create an interactive web-linked CD that will enable all interested stakeholders to obtain the information they want and at the level they can understand on the current status of the Cayuga Lake Watershed.

Methodology:

A CD is being prepared that provides easy access to, and interactive use of, material contained in three recent publications, and to related web pages for users connected to the Internet. The three publications are "Issues in the Cayuga Lake Watershed," "Cayuga Lake Restoration and Protection Plan (RPP)" and "Water Quality Study of the Finger Lakes" by C. Callinan. The Cayuga Lake Watershed Network and the Cayuga Lake Watershed Intermunicipal Organization will be distributing the CD holding informational meetings on the use of the CD. They will also be incorporating it as one of their public relations promotional tools.

This work is being carried out primarily by individuals at the Ithaca Environmental Laboratories, led by Dr. Jose Lozano, Director. Members of the Intermunicipal Organization and the Cayuga Lake Watershed Network are contributing to the design and content of this CD.

Principal Findings & Significance:

Providing content for the CD has been the biggest and most time consuming task. The interactive structure or framework of the CD has been established, with minor modifications yet to be made. Content is now being inserted into this framework. The remaining activities will be devoted to providing easy interactive access to information at various levels of understanding and detail, creating a separate web page for updated information as it becomes available and containing questions and programs and models that will make this web-linked CD more useful as an educational tool for use in schools.

Notable Achievements:

The Cayuga Lake Watershed Education Program Web-linked Interactive CD (i-CD) has been incorporated as an educational task of the Cayuga Lake Watershed Restoration and Protection Plan (RPP). The RPP was produced by the Cayuga Lake Intermunicipal Organization, a multi-jurisdictional watershed-wide local governments association. The production and publication of the i-CD will be done in coordination with the IO, to include the RPP and the Cayuga Lake Characterization Report.

The City of Ithaca has incorporated the i-CD, as a public education resource, to its Stormwater Management program.

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	10	0	0	3	13
Masters	9	3	1	1	14
Ph.D.	6	0	0	0	6
Post-Doc.	0	0	0	0	0
Total	25	3	1	4	33

Notable Awards and Achievements

(See also individual project reports.)

The National Water Education for Teachers (WET) Project has an acclaimed success in educating and informing youth K-12 in all aspects of water resources. New Yorks Project WET, modeled after, and supported by, National WET continues to be a priority for WRI for the third year running. The program is funded by the NYS Department of Environmental Conservation (DEC), Division of Water and conducted in partnership with the NYS Department of Environmental Conservation, Bureau of Environmental Education. Three WRI Water Education Specialists continue to help develop and carry out the program with support through an advisory team.

One measure of success of the WET program is reflected in the under two thousand educators who participated in WET educator and facilitator workshops by the end of the 2002 calendar year. Greater than eighty percent of the elementary, secondary, middle school, and high school teachers, pre-service teachers college faculty, special education specialists, nature center affiliates and curriculum specialists attending workshops, rated their workshop as excellent. A feature of the workshop for all attendees is the distribution of the Project WET Curriculum and Activity Guide. Covering kindergarten through twelfth grades, the Guide is a collection of innovative, water related activities that are easy to use, hands-on and fun.

The Water education specialists participate in, and also sponsor, special water activities for educators and children across the state. Approximately 7,000 students took part in 100 WET activities throughout New York State in 2002. Examples of these events are: Environmental Educational Centers special events; conferences; water education days; stream monitoring; conservation days; science fairs; pond ecology classes; and canoeing programs. This year several Teacher Institutes celebrating 30 years of progress under the Clean Water Act were held. They included a Hudson River Institute, Celebration of WET and WILD, and an Earth Sciences Institute.

Water Education Day is celebrated by each state in September by holding a Make-A-Splash Festival on the same day. The Festival consists of structured learning stations and exhibits where students actively engage in hands-on water activities and investigations. Station topics consisted of the hydrologic cycle, ground water, watersheds, and properties of water. Make a Splash water festivals are designed to emphasize water education principles within a fun, interactive environment.

Given the success of New Yorks Project WET, WET team members for 2003 have been requested to prepare materials and develop a strategy to assist municipal MS4s by demonstrating how to include education and outreach as part of their stormwater management programs. This will insure tomorrows citizens view water not only as a shared resource but also as a shared responsibility.

Publications from Prior Projects

None