New York State Water Resources Institute
Annual Technical Report
FY 2009

Introduction

The Mission of the New York State Water Resources Institute (WRI) is to improve the management of water resources in New York State and the nation. As a federally and state mandated institution located at Cornell University, WRI is uniquely situated to access scientific and technical resources that are relevant to New York State's and the nation's water management needs. WRI collaborates with regional, state, and national partners to increase awareness of emerging water resources issues and to develop and assess new water management technologies and policies. WRI connects the water research and water management communities. Collaboration with New York partners is undertaken in order to: 1) Build and maintain a broad, active network of water resources researchers and managers, 2)Bring together water researchers and water resources managers to address critical water resource problems, and 3)identify, adopt, develop and make available resources to improve information transfer on water resources management and technologies to educators, managers, and policy makers.

Research Program Introduction

WRI's FY09 competitive grants research program was conducted in partnership with the NYS Department of Environmental Conservation and the Hudson River Estuary Program (HREP). The specific areas of interest for the FY2009 grants program were: 1) Research that addresses key knowledge gaps or issues of emerging importance; 2) Projects that integrate technical, legal and social expertise to promote innovative, watershed management strategies; and 3) Development of novel methods for knowledge transfer that enhance the communication of scientific research to teachers, technical providers or to watershed communities. Projects were evaluated by a panel consisting of representatives of the US Geological Survey, the NYS Department of Environmental Conservation (DEC), and faculty from Cornell University. In total, six research projects were supported in FY09 through the competitive grants program with a total funding level of $89,895 ($49,952 USGS 104B, $39,943 HREP). These projects included:

1. Silica dynamics and nutrient retention modeling in the Hudon River Watershed. PIs: Dr. Bob Howarth and Dennis Swaney, Dept. of Ecology and Evolutionary Biology, Cornell University

2. Assessment of drug degradation in New York State Waters. PI: Dr. Anthony Hay, Dept. of Microbiology, Cornell University

3. Restoring access to American eel habitat in tributaries to the Hudson River Estuary: Identifying opportunities and implications for stream communities. PI: Dr. Catherine O'Reilly, Dept. of Biology, Bard College

4. Performance of a retrofit stormwater treatment system in an institutional setting, New Paltz, NY., PI: Larry Goehring, Dept. of Biological and Environmental Engineering, Cornell University

5. Investigation of roadside ditches as contributors to in-stream bank erosion, suspended sediment loads, and degraded water quality across New York. PI: Dr. Rebecca Schneider, Dept. of Natural Resources, Cornell University

6. The fate of non-point sources of nitrate in lawn maintenance, PIs: Dr. Henry Bokuniewicz and Dr. Gilbert Hanson, Dept. of Gesciences, SUNY Stony Brook

Silica dynamics and nutrient retention modeling in the Hudson River Watershed

Basic Information

Title:	Silica dynamics and nutrient retention modeling in the Hudson River Watershed
Project Number:	2009NY116B
Start Date:	3/1/2009
End Date:	2/28/2010
Funding Source:	104B
Congressional District:	22
Research Category:	Water Quality
Focus Category:	Hydrogeochemistry, Ecology, Nutrients
Descriptors:	None
Principal Investigators:	Robert W Howarth, Dennis Swaney

Publications

There are no publications.

FINAL REPORT TO THE
NEW YORK STATE WATER RESOURCES INSTITUTE

Silica dynamics and nutrient retention modeling for the Hudson River Watershed

Dennis P. Swaney, Bongghi Hong, and Robert W. Howarth

MAY 14, 2010

Project Duration: March, 2009-February, 2010.
Principal investigator: Robert W. Howarth, Department of Ecology And Evolutionary Biology, Cornell University, Ithaca, NY 14853 (rwh2@cornell.edu)
Co-investigator: Dennis P. Swaney, Department of Ecology And Evolutionary Biology, Cornell University, Ithaca, NY 14853 (dps1@cornell.edu)
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1) Problem and Research Objectives

The Hudson River watershed is subject to changes in land use and climate which affect nutrient levels and trophic status of its waters, but the details of controls on nutrient loads to its river reaches and estuary are complex. Biogeochemical processes are complicated by regional interactions of nutrients, including nitrogen (N), phosphorus (P) and silica (Si), in tributary streams and the estuary. Understanding how these processes affect the magnitude and transformations of the nutrient loads is necessary to manage the environmental resources of the region. It is important for those living in the watershed to understand the impacts of their activities and policies on these nutrient loads. Modeling tools that integrate the patterns of nutrient sources, landscape, and in-stream processes can improve our ability to manage and communicate the effects of human activities and environmental processes on nutrient loads. While excess N and P are typically held responsible for eutrophication problems, a recent report of the National Academy of Science's Committee on Causes and Management of Coastal Eutrophication noted the importance of Si delivery to estuaries, and the implications of Si limitation in the frequency of harmful algal blooms (HABs) (5). Given the Hudson's comparatively low levels of Si (8) and the known relationships between dams and Si depletion in rivers (2) improving knowledge of Si dynamics in the Hudson watershed should be a priority. We have adapted a national scale, lithology-based typology for Si flux (3) to estimate Si source concentrations and fluxes for Hudson subwatersheds. Proportions of different bedrock categories relating to Si production by chemical weathering were calculated for major subbasins of the Hudson and used in combination with stream discharge with a statistical flux estimation equation (3) to test its

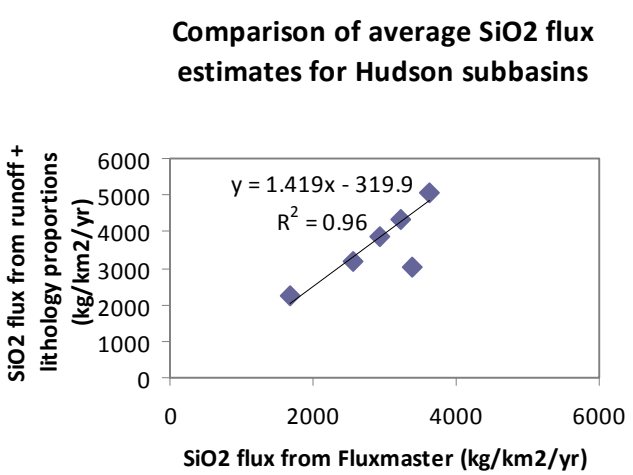

Figure 1. Lithology-based SiO_2 average flux estimates vs. those of the USGS Fluxmaster regression, 1988-93. The estimates correlate well across subbasins, with the lithology based model systematically predicting higher fluxes than fluxmaster, except for the Wallkilll..

validity in the Hudson. Preliminary comparisons between Si flux estimates made with this simple model and corresponding flux estimates made from Si and discharge observations using the USGS Fluxmaster software (7) indicate that the new model captures spatial and temporal variation of Si in the Hudson watershed (Figure 1). In ongoing work, we are modifying the Regional Nutrient Management model (ReNuMa), developed previously as a watershed management tool, to address the priorities of improving estimates of nutrient retention and likelihood of HAB occurrence in the waters of the Hudson/Mohawk. Implementation of the full model will enable calculation of temporal variation of theIndicator for N-limited Coastal Eutrophication Potential (N-ICEP, 1) a silica-based water quality indicator, at several locations in the Hudson estuary.

2) Methods, procedures, and facilities.

All project work was conducted on the Cornell campus using existing resources (computer hardware, GIS software, and models developed in-house) and datasets available online from public sources.

Datasets. Silica and other nutrient data used to infer in-stream nutrient uptake and calibrate the model were obtained from publicly available USGS datasets (http://waterdata.usgs.gov/nwis). Swaney et al. (9) compiled a dataset on Hudson River dams from publicly available sources (11). These data were used to develop subbasin-level explanatory variables (dam density, impoundment capacity) for statistical analyses to estimate effects related to silica trapping (2,12).

GIS analysis. GIS (ArcGIS 9.2) was used to extract relevant digital elevation model and land use/land cover data for watersheds from national or regional datasets. Protocols for many of the procedures developed previously by our group have been made available online (http://www.eeb.cornell.edu/biogeo/nanc/GIS_methods/GIS_methods.htm).

Flux estimation using USGS Fluxmaster model. We acquired the most recent version of the USGS Fluxmaster estimation package (Richard Alexander, USGS, personal communication) to generate monthly and annual estimates of nutrient fluxes from available observations of nutrient concentration and discharge for several measurement stations throughout the Hudson. These have served as the basis for our preliminary assessment of our independent estimates of Si flux, and to calculate nutrient ratios in the Hudson.

Model development. To continue our development of ReNuMa (i.e., to add predictive capability for silica flux) we adapted the Si-lithology map of Jansen et al. (3) for the Hudson, calculated the proportion (p_{ij}) of various lithological categories for each of the Hudson subbasins (table 1), and applied the Jansen et al flux estimate to estimate the corresponding Si flux for each subbasin:

$$F_j = 0.028\sum_{i=1}^{n} p_{ij} q^{b_i} \qquad (1$$

Where F_j is the DSi flux (metric tons km^{-2} yr^{-1}) and q_j the discharge (mm yr^{-1}) from subbasin $_j$, and $b_1 \ldots b_n$ are parameters (Table 1). An equation of similar form for DSi concentration will be the basis for the modification of ReNuMa to accommodate Si flux estimates.

Information transfer strategies. The primary mode of dissemination of the model and associated information (user's guide, datasets, etc) is via the internet. GIS datasets developed by the project for modeling subwatersheds in the region, including digital elevation, soil, land use/land cover, atmospheric deposition data, and derived coverages are made available for public use by placing them in the CUGIR data depository at Mann Library (http://cugir.mannlib.cornell.edu/). Protocols for analyzing the dataset using GIS and other methods will be posted on the protocol website (http://www.eeb.cornell.edu/biogeo/nanc/GIS_methods/GIS_methods.htm). The version of ReNuMa developed for the project, including the data specific to individual watersheds will be

made available for regional watershed and estuary managers by posting it on the ReNuMa website (http://www.eeb.cornell.edu/biogeo/nanc/usda/renuma.htm). We also plan to publish the relevant results on the Hudson in a peer-reviewed journal, and to present ongoing work at scientific conferences.

3) Principal Findings and Significance

Modeling nutrients in large basins. ReNuMa, a hydrologically-driven, quasi-empirical model designed to estimate nutrient fluxes, is currently being used to estimate nitrogen fluxes from subwatersheds to the Hudson estuary within the overall Hudson basin, as well as in several other watersheds. As a result of this project, it is being modified to incorporate silica fluxes as well.

Table 1. Percentage area of lithological categories and discharge exponent parameters (3) used to estimate Si flux in Hudson subbasins.

Subbasin name, station code	Siliciclastic sedimentary (ss)	Metamorphic (mt)	Carbonate sedimentary (sc)	Unconsolidated sediments (su)	Mixed sedimentary (sm)	Waterbodies (wb)
01325010 HUDSON RIVER SOUTH OF LAKE LUZERNE NY	0.58	87.09	4.43	4.24	-	2.32
01335770 HUDSON RIVER AT WATERFORD NY	21.45	62.87	7.77	3.36	1.85	1.82
01351450 SCHOHARIE CREEK AT ESPERANCE NY	89.17	-	5.54	-	5.01	0.28
01357500 MOHAWK RIVER AT COHOES NY	61.21	16.25	12.02	5.77	4.26	0.49
01358000 HUDSON RIVER AT GREEN ISLAND NY	38.52	42.85	9.59	4.40	2.88	1.25
01371500 WALLKILL RIVER AT GARDINER NY	69.79	10.48	16.81	-	-	0.17
b_i parameters (exponents)	0.717	0.793	0.776	0.797	0.753	

Dissolved silicon (DSi) is different from other nutrients in that the major significant source is the weathering of bedrock containing Si-bearing minerals, and thus is driven by factors that affect weathering, including variations of precipitation and temperature (13) or simply hydrology. ReNuMa is quasi-empirical in that it makes no attempt to model detailed mechanisms of biogeochemical processes; most relationships in the model are based on empirical response functions and mass balance. We are maintaining a parsimonious approach with DSi, treating its riverine flux primarily as the result of the weathering of bedrock sources based on recent work on silica lithology (Figure 2) and ongoing work on in-stream uptake of Si and retention behind dams in the subbasins (Figure 3). It is also evident from work to date that variation of Si sources in the Hudson will be strongly dependent upon hydrology (discharge) as an integrator of climate and, presumably, its effect on Si weathering.

Watershed-scale nutrient fluxes and nutrient ratios. Based on USGS data for the Upper Hudson, Mohawk, and the Wallkill over several years, seasonal variation in total nitrogen and SiO_2 fluxes were estimated from the subbasins shown in table 1. From these fluxes, estimates of the variation of molar ratio of Si:N were also determined. Figure 4 shows estimates of the ratio for Hudson subbasins. Two significant patterns are evident in these ratios:

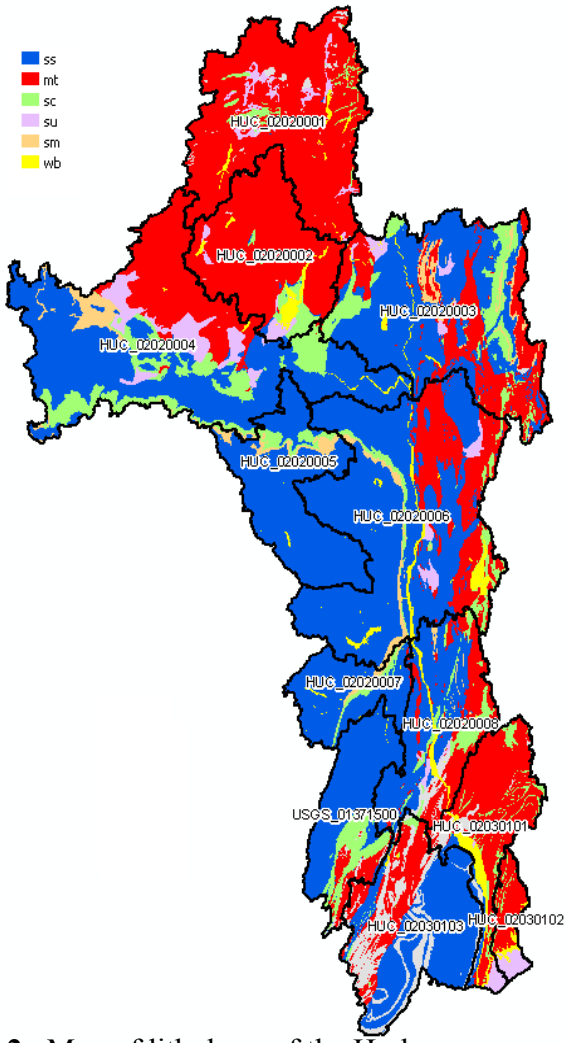

Figure 2. Map of lithology of the Hudson catchment. SS=Siliciclastic sedimentary rocks, MT=Metamorphic rocks, SC=Carbonate sedimentary rocks, SU= Unconsolidated sediments, SM= Mixed sedimentary rocks, WB= Water bodies (Derived from Jansen et al., 2010). Major hydrologic units (subbasins) of the Hudson are indicated by their USGS codes

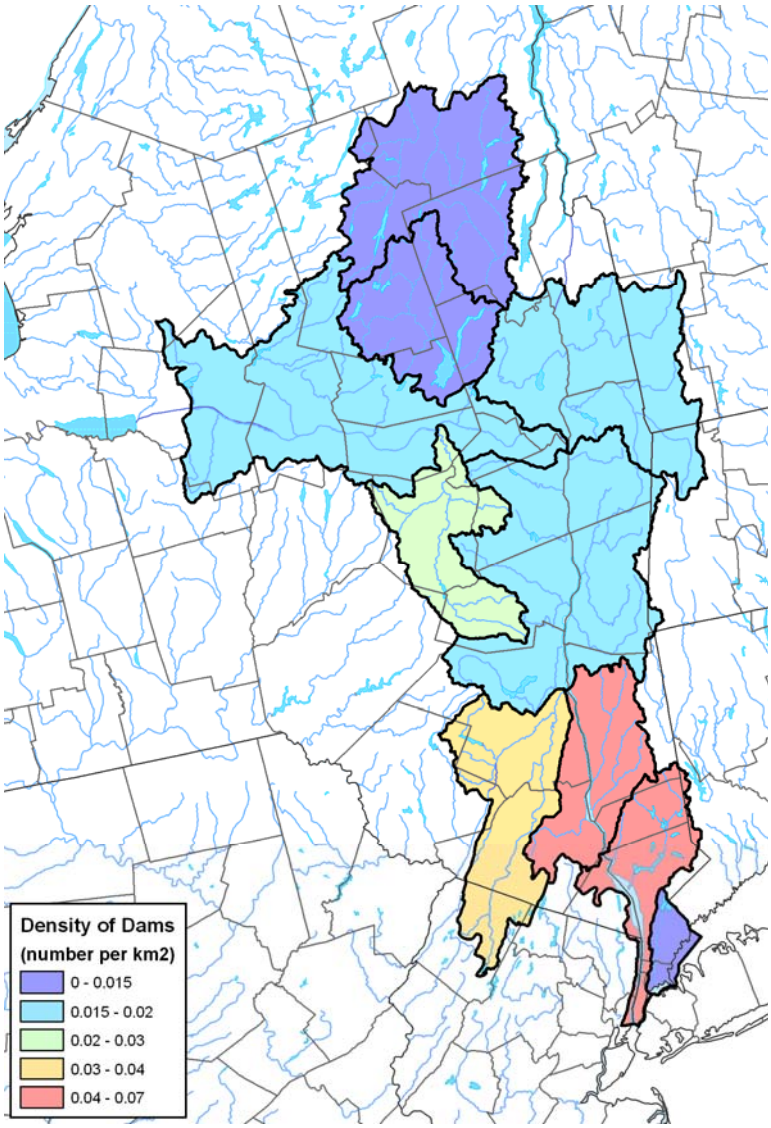

Figure 3. Density of dams in major subbasins of the Hudson drainage (data from Swaney et al., 2006)

1) Strong seasonality is present in the signal for all watersheds, with minimal values occurring in spring or summer, and maximal values in fall or winter. Some differences in the timing of the peaks and troughs are apparent across the Hudson subbasins

2) Marked differences in the mean value of the Si:N ratio exist between the relatively highly forested watersheds of the Upper Hudson and agriculturally dominated watersheds of the lower Hudson and Mohawk.

Seasonality is present in both Si and TN flux time series (not shown), though their ratio generally follows a smoother oscillatory trend than those of the individual fluxes because of their occasionally abrupt changes associated with extremes in hydrological variation; the ratio may be a better indicator of the joint dependence of these nutrients on seasonally varying biological processes. The changes in magnitude of Si:N from forested to agricultural landscapes reflects the relatively low N loading of the Upper Hudson above Green Island and Lake Lucerne stations compared to those in the Mohawk and especially the

Wallkill. Maximum fluxes of SiO_2 often occur winter months in the watersheds, suggesting that these are due to low biological activity across watersheds. Summertime flux magnitudes can differ substantially in both degree and timing across watersheds, suggesting significant watershed-scale differences in in-stream retention. The Schoharie typically has the lowest Si yield throughout most of the year, perhaps indicating the effect of its relatively high degree of damming. Our ongoing work to characterize seasonal flux and retention across watersheds, along with those of other nutrients, is improving our understanding of dynamics of nutrient load to the Hudson estuary.

Silica, the food chain, and HABs. Another reason to pay attention to nutrient ratios as well as magnitudes of individual fluxes is that the magnitudes of nutrient fluxes *in relation to each other* play a role in determining the balance of different functional groups of phytoplankton and higher plants in the estuary. Diatoms, which require Si to form their characteristic skeletal "frustules" are for the most part considered relatively benign members of the algal community, and dominate many freshwater and estuarine ecosystems. At the base of the food chain, they serve as critical food sources for estuarine zooplankton, which in turn support larval fish production. When Si concentrations are low, they may be outcompeted by algal species that do not require Si, including some species which exhibit undesirable and even toxic characteristics (4, 6). Evidence suggests that when Si:DIN molar ratios fall below 1, the food chain support declines (10). Figure 4 shows that over the seven year period analyzed, the forested Upper Hudson watersheds generate Si and TN fluxes well in excess of a 1:1 molar ratio, while the ratio from the highly agricultural Wallkill was below 1:1 most of the time, occasionally exceeding it in winter months. Other watersheds fell somewhere in between, seasonally dipping below the 1:1 ratio, depending upon the balance of N and Si supply and demand within each subbasin. The relative contributions of regionally and seasonally varying fluxes across basins have consequences for the composition of the Hudson estuarine phytoplankton communities, and by extension, the health of the Hudson River food web.

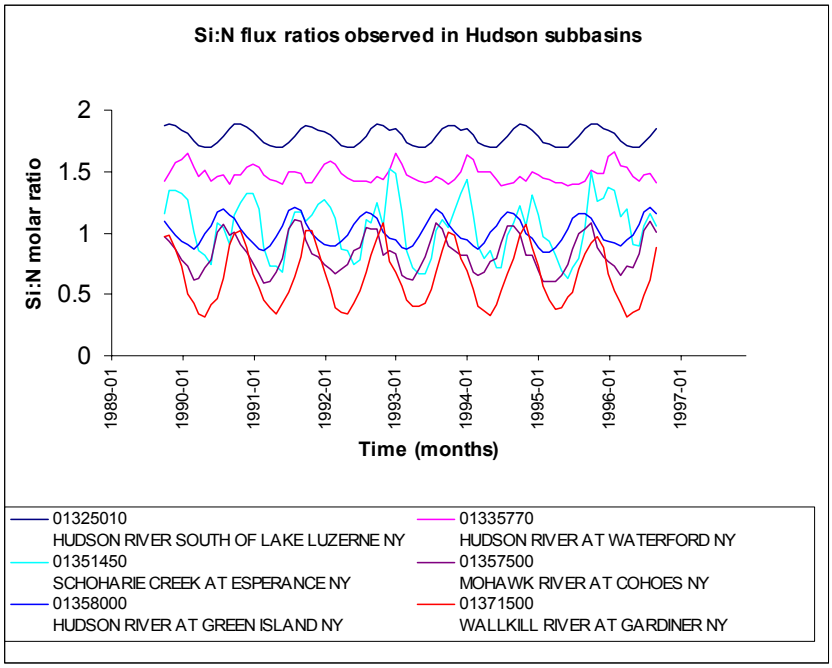

Figure 4. Temporal variation in Si:N molar ratios for some subbasins of the Hudson for water years 19901996 based on monthly fluxes of Si and TN.

Student support

No students have been supported by this grant.

Publications and presentations associated with the project

To date, we have made no presentations related to the outcomes of the project, though a poster is under development. When we complete analysis of the data developed in the project, we will write a paper summarizing observed Si and N dynamics in major subbasins of the Hudson, based on observed fluxes. An additional paper on the adaptations of ReNuMa to handle silica fluxes is also under consideration.

Other opportunities or collaborations enabled by the grant

This grant was fundamental in promoting our initial communication with Nils Jansen, who, with other European colleagues, developed a Si-lithology typology for the continental US, and agreed to share their dataset with us. It provided the basis for our corresponding lithology map for the Hudson watershed, and further developments with Si modeling. We anticipate additional interest by other researchers in Upstate New York (e.g., SUNY-ESF) and elsewhere in collaborations to investigate couple Si-N dynamics in New York watersheds.

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Assessment of drug degradation in New York State waters

Basic Information

Title:	Assessment of drug degradation in New York State waters
Project Number:	2009NY117B
Start Date:	3/1/2009
End Date:	2/28/2010
Funding Source:	104B
Congressional District:	22
Research Category:	Water Quality
Focus Category:	Wastewater, Water Quality, Methods
Descriptors:	None
Principal Investigators:	Anthony Hay, Patrick Phillips

Publications

There are no publications.

Assessment of Drug Degradation in New York State Waters

Anthony Hay[1] & Patrick Phillips[2]
[1]Cornell University, Dept. of Microbiology
[2] US Geological Survey, Troy, NY

1. Problem Statement and Research Objectives

Every day humans release hundreds of biologically active pharmaceuticals and personal care products (PPCPs) into receiving waters, yet we know surprisingly little about the environmental fate of these compounds and what risks they pose. Recent studies have revealed the presence of pharmaceuticals in surface waters across the country, and research by Co-PI Phillips has documented the presence of opiates, barbiturates, muscle relaxants and other pharmaceuticals in streams and wastewater treatment plants (WWTPs) in New York State. Concentrations of opiates were unusually high (over 1,000ug/L in some cases) at a WWTP which receives discharge from an opiates manufacturing facility. This suggests that pharmaceutical manufacturing facilities (PMFs) may be a major source of pharmaceutical contamination in NY waters. This and other WWTPs are continued to be evaluated as part of our project.

For the 2009 award, we proposed to examine the biodegradation of pharmaceuticals at WWTPs that are impacted by PMFs, and conduct controlled studies with laboratory microcosms that simulate WWTPs to quantify the biodegradation of selected pharmaceuticals. This work is important because everyone is concerned about having clean water for themselves and for the environment. The public wants to know what is in their water and if it is harmful. WWTP operators need to know what is getting by them and what can be done to stop it. Regulators and risk assessors need to know what happens to these compounds once they get into the environment. This information is necessary before a complete risk assessment can be done for these compounds and before we can determine what steps need to be taken to further address the issue of pharmaceutical contamination of our water.

Very little is known about opiate degradation during the wastewater treatment process. What is known is that several of the opiates and opioids are similar in structure and can be metabolically transformed into one another by laboratory cultures of individual bacteria (Bruce et al 1994). We will be determining if these compounds are transformed into one another during wastewater treatment. This will assist engineers that are evaluating removal processes by improving their mass balance assessment. We have begun to determine the degradation rates for selected pharmaceuticals and identify metabolites formed during biodegradation. This will help us to understand the fate of these industrial wastes that are being discharged into municipal treatment plants.

We have worked with Co-PI Pat Phillips to select two WWTPs impacted by PMFs, one impacted by a hospital, and one that uses a lower efficiency trickle filter for the secondary treatment step.

2. Methods

Bioreactors

10L carboys were outfitted to mimic the aeration tanks in WWTPs and used to study the identity and kinetics of metabolite formation from pharmaceuticals. The bioreactors are operated with agitation and aeration using a magnetic stir bar and a stream of air from a glass tube. WWTP activated sludge is used for media and adjusted to approximately 2g/L of suspended solids composed of microbial mass and organic matter. OECD 302b testing guideline methods were adopted to wash the sludge so we could remove the pollutants from the source of the microbial communities. We have assessed ibuprofen degradation (since we were unable to obtain) as we are optimizing methods for operation and sampling of the bioreactors. The optimization run was prepared with 50ppm ibuprofen and the abiotic treatment was provided with 600ppm silver as a biocide. Samples are taken to determine percent removal of the parent compounds and to identify metabolites. Chemical analysis for ibuprofen degradation was conducted by HPLC as described by Murdoch & Hay (2005), and future analysis of our target pharmaceuticals will be conducted via GC-MS as described in the chemical analysis section below. The first set of selected pharmaceuticals is the opiates.

Field Samples

We are collecting samples from WWTPs to evaluate the removal of pharmaceuticals throughout the process. Sites have been selected that are impacted by sources such as PMFs and hospitals, with a special focus on an opiates impacted site. For chemical analysis, the samples are collected in Teflon bottles and shipped over night on ice to the U.S.G.S. National Water Quality Lab (NWQL) in Denver, Co. The sample collection method also varies according to the location. At the WWTPs, samples are collected over a 24hr period using an ISCO 6700 series autosampler and composite samples are analyzed for each of the following: influent, clarification tank, and effluent. At field sites throughout the Hudson River watershed, grab samples are taken using a weighted sampler or a pole sampler.

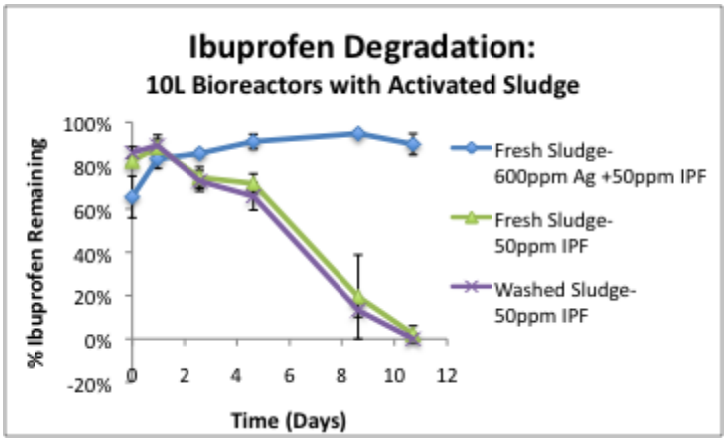
Chemical Analysis

The field samples have been sent for processing at the NWQL according to an internal protocol for common wastewater pollutants and pharmaceuticals (schedules 1433 & 2080). The NWQL method is similar to those described in recent studies (Hummel *et al*. 2006, Boleda *et al.* 2007, Castiglioni *et al.* 2006). Briefly, samples are filtered through a fiberglass filter, spiked with isotopically labeled surrogate standards, extracted with Oasis HLB cartridges, and analyzed by GC/MS

(Phillips *et al.* publication pending). We will be using the same protocol to analyze bioreactor samples in P.I Dr. Hay's lab. While these analytical chemistry methods examine around 100 compounds, the focus of our work with the bioreactors is opiates and will target the following analytes: codeine, hydrocodone, oxycodone, dihydrocodone, morphine, hydromorphone, oxymorphone, and dihydromorphone.

3. Principle Findings and Significance.

We have made progress both in collecting samples in the field and optimizing the operation of the bioreactors. Eighteen field samples for the WRI project have been taken so far. Three of these samples were composite samples for the influent, intermediate, and effluent stages of wastewater treatment at a PMF affected WWTP and these will be analyzed using schedules 1433 and 2080 to evaluate the degradation of specific opiates known to be present in high concentrations at this site. These include six samples throughout the Hudson River watershed and nine from WWTP effluents. Chemical analysis has been delayed because furloughs have set back the processing time at the NWQL. For this reason we do not have any data to report on the field samples.



The bioreactors have been built and a preliminary biodegradation assay has been conducted using ibuprofen. Activated sludge was collected from the Ithaca WWTP and media was prepared with washed sludge and fresh sludge to assess the biodegradative potential of the washed sludge. Biological activity was inhibited with 600ppm of silver to assess abiotic removal. Ibuprofen removal was achieved within 11 days, figure. Abiotic removal only accounted for 10%, as shown in the silver and ibuprofen treatment. Media derived from fresh and washed sludges degraded ibuprofen at essentially the same rate, which confirms that the aromatic degradation community is not greatly impacted by the washing step.

Our bioreactor experiments with the opiates has been delayed because of the bureaucratic hurdles involved in getting a permit to work with these compounds. For this reason, and the delay in analyses at the USGS we asked for and were a granted a one year no cost extension. One other piece of the washing step must be confirmed prior to beginning our opiates biodegradation assay using bioreactors. The activated sludge from the PMF impacted site will have its normal burden of opiates and their degradation products present and the wash step must remove them so they don't interfere with our chemical analysis. Up to 2ppm of opiates have been detected but more commonly they are present at a couple hundred ppb. Activated sludge has been collected from the PMF affected WWTP and a sample has

been stored for analysis. The sludge was washed, incubated with aeration and agitation for 24hrs to allow chemicals to desorb from the solids, and a sample was stored for analysis. These samples will be analyzed for opiates and metabolites.

We are also in the process of setting up our lab for the chemical analysis protocol used at the NWQL lab. We have successfully used the GCMS protocol to detect codeine, hydrocodone, oxycodone, and morphine. We have finally been able purchased now that we have the appropriate permit and we have set up an extraction manifold for solid phase extraction required to prepare the samples from the bioreactor. The remaining portion of the chemical analysis optimization is currently underway.

4. Additional Information

Student Support

Ph. D candidate Amy Risen has benefited from this award as the research conducted will be included in her dissertation. Funding has enabled the purchase of supplies, the outsourcing of analyses steps at other facilities, and travel to sampling sites. Her stipend support has been obtained through a U.S.G.S. Graduate Assistantship at the Ithaca, NY office where she assists with the 305b groundwater sampling program. One goal of the student funding program is to encourage students to collaborate with other U.S.G.S. scientists. This research is a result of a collaboration with Pat Phillips in the Albany, NY office and the WRI award has supported this work.

Publications and Presentations

Amy Risen gave an oral presentation at the 2009 Emerging Contaminants conference in Fort Collins, Co. entitled "Pharmaceuticals, precursors & metabolites in wastewater impacted by pharmaceutical manufacturing facilities".

Other Opportunities or Collaborations that were Enabled by the Grant

The 2009 WRI award has allowed us to begin a new line of research in the lab. At first it opened up opportunities for collaboration with the U.S.G.S. Then we elaborated on our research goals and were awarded funding from the NYDEC's Hudson River Estuaries Program (HREP). Our project goals with HREP are similar but focus more on sites that are currently being monitored by the Hudson River Environmental Conditions Observing System.

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Restoring access to American eel habitat in tributaries to the Hudson River Estuary: Identifying opportunities and implications for stream communities

Basic Information

Title:	Restoring access to American eel habitat in tributaries to the Hudson River Estuary: Identifying opportunities and implications for stream communities
Project Number:	2009NY118B
Start Date:	3/1/2009
End Date:	12/31/2010
Funding Source:	104B
Congressional District:	22
Research Category:	Biological Sciences
Focus Category:	Conservation, Ecology, Water Use
Descriptors:	None
Principal Investigators:	Catherine O'Reilly, Robert Schmidt

Publications

There are no publications.

WRI/HREP Grant 2009

Saw Kill Eel Project Report

Restoring access to American eel habitat in tributaries to the Hudson River Estuary: Identifying opportunities and implications for stream communities

Participants

Principal investigators: Dr. Catherine O'Reilly (Bard College) and Dr. Robert Schmidt (Simon's Rock College of Bard)
Collaborators: Dan Miller (Hudson River Estuary Program/DEC), Chris Bowser (Hudson River Estuary Program/DEC)

Statement of the problem and Research objectives

Populations of American eels (*Anguilla rostrata*) have been declining for several reasons, including loss of habitat (Haro et al. 2000). In the Hudson River estuary, access to upstream habitat is severely restricted by numerous small dams that act as barriers to many miles of viable habitat upstream. From our previous work on the Saw Kill, we know that eel ladders can provide effective passageway over barriers and increase access to upstream habitat. In order to continue effective restoration of the American eel population, we need to identify other tributaries that would be appropriate for restoration projects, which will require assessment of barriers, existing eel populations, and incoming glass eel migrations. We propose to work with high school and college students to assess 7 tributaries to the Hudson River to prioritize sites for restoration. Our objectives are to determine the numbers of incoming glass eels in the spring migration at various tributaries. This approach will both help identify tributaries that have high numbers of incoming eels, and will also engage students and citizen scientists.

Methods

Fyke nets

To help assess glass eel migration into Hudson River tributaries, we collected data on incoming glass eels from several tributaries using fyke nets. Each fyke net was primarily sampled by local citizen scientists or high school students, under supervision of DEC education staff Chris Bowser and Sarah Mount. College interns helped prepare the nets for deployment (Fig 1). Preparations began in fall and winter, with spring sampling commencing in 2010. This grant funded 4 fyke nets for new sites in addition to the sampling done at the Saw Kill, although through additional funding our sampling was expanded to 9 sites (Table 1). The fyke net sites ranged from Westchester to Greene County, and involved approximately 250 regular volunteers and 1200 participants in classroom and field programs directly related to the eel project. The full list of spring 2010 sites with volunteers is provided in Appendix 1.

Table 1. Location of the fyke nets in spring 2010.

Stream	County
Hannacroix Creek*	Greene
Saw Kill*	Dutchess
Black Creek*	Ulster
Crum Elbow Creek*	Dutchess
Fall Kill	Dutchess
Indian Brooke	Putnam
Furnace Brook	Westchester
Minnisceongo*	Rockland
Saw Mill	Westchester

* Funded by WRI grant

Artificial habitat collectors

In addition, we tested a simple device that could facilitate data collection in sites where a fyke net is not feasible. An alternative to fyke nets are artificial habitat collectors, which are plastic saucers with tufts of polyethylene split rope fiber that have been successful for sampling larvae of other eel species (Silberschneider et al. 2001). The advantage of these collectors is that they do not need to be sampled every day and can be much more easily placed in a variety of locations at one site. Artificial habitat collectors have the potential to expand outreach and education programs with high schools because they are cheap and simple to sample, and if effective, they could be used to sample glass eels in Hudson River, where fyke nets are ineffective. We conducted a comparison between the efficiency of glass eel capture by artificial habitat collectors vs fyke nets in the Saw Kill and south Tivoli Bay.

Eel passage

Dan Miller and other DEC fisheries staff have also designed a highly portably and adjustable eel passage device, based on the one currently used at the Saw Kill. The plan is to deploy this passage device at one of the sites this summer.

Principle findings and significance

Fyke nets

We have found that the fyke nets have provided useful information about the glass eel migration. Southern tributaries seem to have higher numbers of glass eels than more upstream tributaries. There is a lot of daily variation in catch, which is not easily attributed to environmental factors such as temperature, tides, or moon phase (Figs 2 and 3). The fyke net data from spring 2010 is still being collected and has not yet been compiled across all sites.

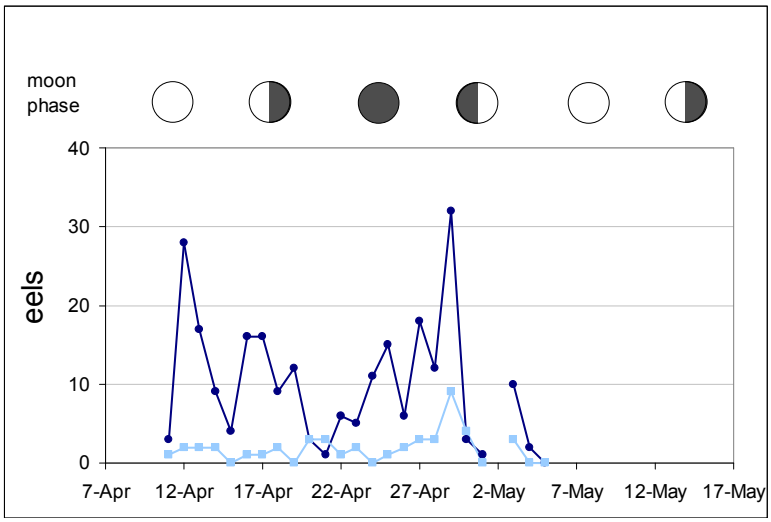


Fig 2. Glass eel (dark blue) and pigmented eel (light blue) catches in the Saw Kill fyke net in spring 2009. Moon phase is also shown.

Artificial habitat collectors

We found that the artificial habitat collectors were successful at sampling glass eels in South Tivoli Bay. The habitat collectors indicated that there was some spatial variation in glass eel distribution in the bay. However, using the artificial collectors was more difficult than using the fyke net, requiring large field buckets and that participants be fairly strong. We concluded that while these can provide information about glass eel presence, they are not as informative or as easy to sample as the fyke nets.

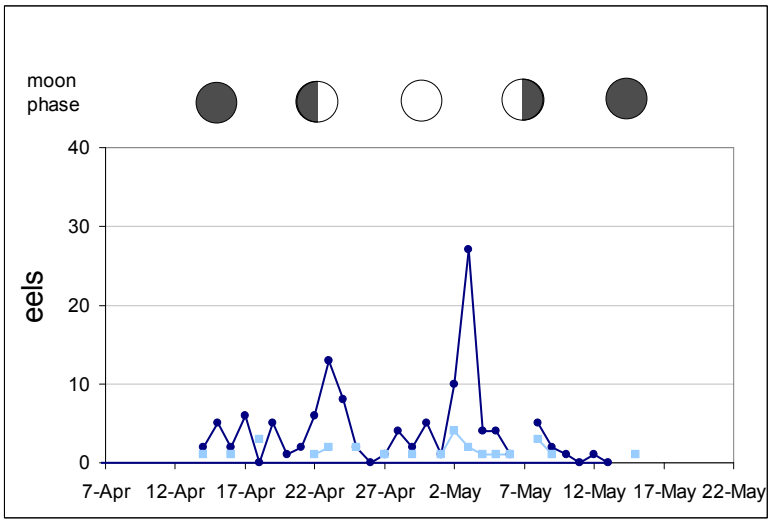


Fig 3. Glass eel (dark blue) and pigmented eel (light blue) catches in the Saw Kill fyke net in spring 2010. Moon phase is also shown.

Eel passage

We are using the data from the fyke nets to determine where to place the new eel passage device this summer.

Description of student support
Students from both high schools and colleges have been involved in sampling the fyke nets. The list below includes participants in spring 2010.

School districts: (total of around 200 students participated in field sampling)

- Ossining High School
- Poughkeepsie High School
- Arlington High School
- Coxsackie-Athens School District (high school and second graders)
- New Paltz High School
- Maple Wood High School
- Kingston High School
- Saunder's High School

Colleges

- Marist and Vassar College (10 students and staff)
- Bard College
  Biology 202 Ecology and Evolution class participated in the fyke net sampling in 2009 and did the assessment of the artificial habitat collectors. (26 students)
  A team of 9 students participated in the fyke net sampling in 2010. (9 students)
- Bard College at Simon's Rock
  Bob Schmidt and 2 students sampled the eel ladder in summer 2009. (2 students)

In addition, several other community groups have been involved (Appendix 1).

Publications and presentations originating from the project

- Catherine O'Reilly and Chris Bowser have given several presentations to high schools and the general public about the project.
- We are also working on a new web site (eels.bard.edu) which is not yet complete. The goal of this web page is to have all the data from each site available, as well as background information about the project and about eels.
- There has also been media coverage in the Poughkeepsie Journal, April 11, the Catskill Daily Mail, May 21, and the Journal News, 25 May.

Description of other opportunities or collaborations that were enabled by the grant

- Additional funding was obtained TogetherGreen Fellowship Program of National Audubon and Toyota and Hudson River Valley Greenway (to Chris Bowser with Catherine O'Reilly as a mentor)
- This grant funded 5 sites for spring sampling using fyke nets. However, we were able to obtain additional funding to expand the network to a total of 9 sites.
- Sarah Mount, Bard College undergraduate, received a Polgar Fellowship to study eel-crayfish interactions. She found that eels and crayfish do not coexist in tributaries to the Hudson River. There were also no non-native crayfish in these tributaries. Her work suggests that eels may act as biocontrols for crayfish invasions.
- Jocelyn Edwards, Bard College undergraduate, conducted an analysis of eel passage on the Saw Kill, and found that eel passage data reflects incoming eel migration data with a time lag of 1 year.
- We are also beginning to think about formalizing the glass eel fyke net citizen science program and acquiring additional funding.

APPENDIX 1

2010 Eel Project of the New York State Department of Environmental Conservation
Hudson River Estuary Program
Hudson River National Estuarine Research Reserve
Bard College
Project Website: http://www.dec.ny.gov/lands/49580.html

Major Supporters
New York State Water Resources Institute at Cornell University
TogetherGreen Fellowship Program of National Audubon and Toyota
Hudson River Valley Greenway

Site Locations and Organizational Partners

Site: Fall Kill
Poughkeepsie, Dutchess County
Mid-Hudson Children's Museum
Poughkeepsie High School
Marist College
Arlington High School
Vassar College

Site: Crum Elbow Creek
Hyde Park, Dutchess County
Marist College
Hyde Park Landing
Vassar College

Site: Saw Kill
Annandale-on-Hudson, Dutchess Co.
Bard College

Site: Hannacroix Creek
New Baltimore, Greene County
Cornell Cooperative Ext. of Greene Co.
Soil & Water Cons. District of Greene Co.
New Baltimore Conservancy
Coxsackie-Athens School District
NYSDEC Five Rivers Environmental Center

Site: Indian Brook
Cold Spring, Putnam County
Constitution Marsh Audubon Sanctuary

Site: Minisceongo Creek
West Haverstraw, Rockland County
Mirant-Bowline
Strawtown Art Studios
Keep Rockland Beautiful
Rockland County Water Quality Committee
West Haverstraw Community Center

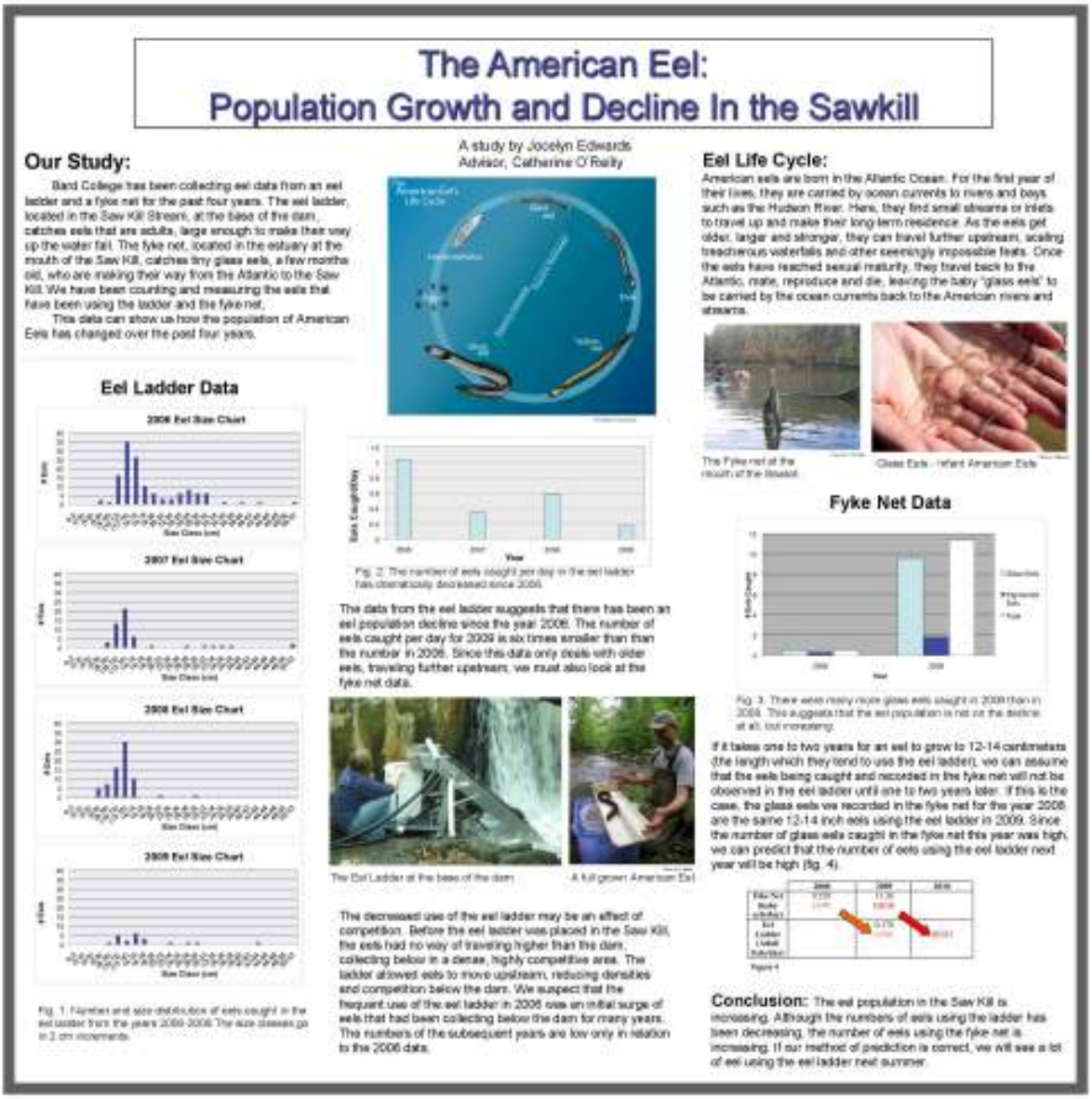
Site: Black Creek
Esopus, Ulster County
Scenic Hudson
Kingston High School
New Paltz Central School District
Marist College
Boy Scouts of America
Maple Ridge High School
Rondout Valley High School

Site: Furnace Brook
Cortlandt, Westchester County
Ossining High School
Putnam/Northern Westchester BOCES

Site: Saw Mill River
Yonkers, Westchester County
Greenburgh Nature Center
Groundwork Yonkers
Beczak Environmental Education Center

APPENDIX 2

Independent Research Poster by Jocelyn Edwards, Bard College undergraduate



The American Eel: Population Growth and Decline In the Sawkill

A study by Jocelyn Edwards
Advisor, Catherine O'Reilly

Our Study:

Bard College has been collecting eel data from an eel ladder and a fyke net for the past four years. The eel ladder, located in the Saw Kill Stream, at the base of the dam, catches eels that are adults, large enough to make their way up the water fall. The fyke net, located in the estuary at the mouth of the Saw Kill, catches tiny glass eels, a few months old, who are making their way from the Atlantic to the Saw Kill. We have been counting and measuring the eels that have been using the ladder and the fyke net.

This data can show us how the population of American Eels has changed over the past four years.

Eel Life Cycle:

American eels are born in the Atlantic Ocean. For the first year of their lives, they are carried by ocean currents to rivers and bays such as the Hudson River. Here, they find small streams or inlets to travel up and make their long-term residence. As the eels get older, larger and stronger, they can travel further upstream, scaling treacherous waterfalls and other seemingly impossible feats. Once the eels have reached sexual maturity, they travel back to the Atlantic, mate, reproduce and die, leaving the baby 'glass eels' to be carried by the ocean currents back to the American rivers and streams.

The Fyke net at the mouth of the Hudson

Glass Eels - Infant American Eels

Eel Ladder Data

2006 Eel Size Chart

2007 Eel Size Chart

2008 Eel Size Chart

2009 Eel Size Chart

Fig. 1. Number and size distribution of eels caught in the eel ladder from the years 2006-2009. The size classes go in 2 cm increments.

Fig. 2. The number of eels caught per day in the eel ladder has dramatically decreased since 2006.

The data from the eel ladder suggests that there has been an eel population decline since the year 2006. The number of eels caught per day for 2009 is six times smaller than than the number in 2006. Since this data only deals with older eels, traveling further upstream, we must also look at the fyke net data.

The Eel Ladder at the base of the dam

A full grown American Eel

The decreased use of the eel ladder may be an effect of competition. Before the eel ladder was placed in the Saw Kill, the eels had no way of traveling higher than the dam, collecting below in a dense, highly competitive area. The ladder allowed eels to move upstream, reducing densities and competition below the dam. We suspect that the frequent use of the eel ladder in 2006 was an initial surge of eels that had been collecting below the dam for many years. The numbers of the subsequent years are low only in relation to the 2006 data.

Fyke Net Data

Fig. 3. There were many more glass eels caught in 2009 than in 2008. This suggests that the eel population is not on the decline at all, but increasing.

If it takes one to two years for an eel to grow to 12-14 centimeters (the length which they tend to use the eel ladder), we can assume that the eels being caught and recorded in the fyke net will not be observed in the eel ladder until one to two years later. If this is the case, the glass eels we recorded in the fyke net for the year 2008 are the same 12-14 inch eels using the eel ladder in 2009. Since the number of glass eels caught in the fyke net this year was high, we can predict that the number of eels using the eel ladder next year will be high (fig. 4).

Figure 4

Conclusion: The eel population in the Saw Kill is increasing. Although the numbers of eels using the ladder has been decreasing, the number of eels using the fyke net is increasing. If our method of prediction is correct, we will see a lot of eel using the eel ladder next summer.

Performance of a Retrofit Stormwater Treatment System in an Institutional Setting, New Paltz, NY.

Basic Information

Title:	Performance of a Retrofit Stormwater Treatment System in an Institutional Setting, New Paltz, NY.
Project Number:	2009NY119B
Start Date:	3/1/2009
End Date:	2/28/2010
Funding Source:	104B
Congressional District:	22
Research Category:	Engineering
Focus Category:	Hydrology, Floods, Law, Institutions, and Policy
Descriptors:	None
Principal Investigators:	Larry D Geohring, Brian Richards, Tammo Steenhuis, Jamie Vanucchi-Hartung

Publications

There are no publications.

Final Project Report for FY2009 WRI Grant

Project Title: Performance of a Retrofit Stormwater Treatment System in an Institutional Setting, New Paltz, NY.

Project Dates: 03/01/2009 to 02/28/2010

Principal Investigators:

Larry D. Geohring, Cornell University, Biological and Environmental Engineering (BEE);
Jamie Vanucchi-Hartung, Cornell University, Landscape Architecture (LA);
Tammo S. Steenhuis, Cornell University, BEE; and
Brian K. Richards, Cornell University, BEE

Problem Statement and Research Objectives:

The Hudson River Estuary Program (HREP) action plan for "Streams and Tributaries" included a goal for stormwater management to "Establish and implement programs to reduce the adverse effects of stormwater runoff from impermeable surfaces, and to use new and existing technologies to maintain and restore wetland and stream hydrology and recharge aquifers by retaining and managing water on site". Stormwater runoff from impervious areas connected directly to streams can cause water quality impairments; and thus, mitigating measures for new development very often try to reduce impervious surfaces or retrofit developed lots to better retain and infiltrate stormwater runoff in the more pervious areas of the developed lot.

The NYS DEC Region 3 office in New Paltz had recently undergone a building and parking lot area expansion which increased the impervious surface area of the site to forty-seven percent. This expansion necessitated some redevelopment of the office complex site and the stormwater runoff handling system was upgraded with the construction of an infiltration basin and detention pond. During the retrofit, the runoff from all the impervious surfaces was diverted directly to the infiltration basin, but it was quickly discovered that this infiltration basin could not adequately infiltrate the quantity of runoff received. The infiltration basin filled and overflowed into the detention pond, and both remained full of water for long periods of time. It was soon recognized that there were some major shortcomings of the drainage design and stormwater management system for the site that hampered the planned performance. Consequently, the site offered an excellent case study opportunity to re-evaluate the site's stormwater drainage plan, and to propose alternatives for better diverting and redistributing the stormwater runoff to other more permeable areas on the site.

The primary research project objectives were to evaluate the drainage and stormwater runoff management system for this case study site, and to plan and design alternatives, preferably a rain garden(s) that could handle more of the stormwater runoff from the expanded roof of the building and possibly from other expanded parking lot areas prior to reaching the infiltration basin. Thus, this project provided an important educational opportunity whereby most of the work would be carried out by Cornell students and local volunteers to audit the site stormwater runoff patterns and handling, and to design the rain garden(s). By engaging students and

volunteers, the project sought three benefits for the lower Hudson Valley which were to: 1) provide input to design criteria for similar sites in the vicinity having similar geotechnical conditions, 2) provide an interdisciplinary experience for students in Cornell University's Biological and Environmental Engineering and Landscape Architecture's Departments in site stormwater design and monitoring, and 3) provide an installation plan for a raingarden(s) that could be installed and utilized for demonstration value in the area. Since stormwater treatment professionals has been an area of job growth recently, particularly after governmental mandates for new development and Federal Municipal Separate Storm Sewer System (MS4) regulations, this project was intended to provide an experiential learning and problem solving experience for students.

Methodology:

The students obtained existing as-built drainage and stormwater management blueprint plans which were prepared for the building and parking lot expansion and re-development of the site, and then conducted on-site visits to audit and evaluate the current performance of the stormwater runoff management system. They interviewed personnel at the site to review the existing drainage problems, and to better determine the local capacity for landscape maintenance and the desired appearance of a proposed rain garden(s) design. They also evaluated the soils in the remaining permeable areas of the site that were planted to turfgrass. Using weather data from the Cary Institute of Ecosystem Studies in nearby Millbrook, New York, the students characterized the hydrologic situation for the area, developed water budgets, and determined the likely stormwater runoff and groundwater recharge that would occur and which could be additionally diverted and infiltrated into the permeable areas. Using engineering and landscape architecture principles and techniques learned during Spring Semester 2009 in BEE 4740 Water and Landscape Engineering Applications and LA 6020 Integrating Theory and Practice II (design studio) classes, combined with guidance and recommendations from the New York State Stormwater Management Design Manual (2003), the students proposed five different rain garden designs and re-landscaping plans. These plans were presented to interested HREP cooperators and NYS DEC Region 3 office personnel, and a final plan was developed and submitted in a proposal to seek and obtain additional funding to implement the revised stormwater runoff management plan.

Principal Findings and Significance:

One of the major significant findings regarding the stormwater management runoff infiltration basin that was constructed during the expansion and redevelopment of the office complex site was that the site's bedrock geology was not conducive for an infiltration basin. The infiltration basin was constructed so that its invert was within a foot of the underlying bedrock, and the bedrock was not a fractured or permeable type of bedrock. Thus, once the stormwater runoff entered the basin, it quickly filled and overflowed, and the only loss and removal of water was via direct evaporation, which was gradual and primarily limited to the summer months. Consequently, the infiltration basin served little purpose to redirect and infiltrate stormwater runoff from the adjacent impervious surfaces, and it had little capacity to drain and to then provide storage for the stormwater runoff for the next storm event. These findings provided some important lessons about understanding the characteristics of a site, how those

characteristics influence the local hydrological response, and how that hydrological response should be evaluated to correctly select and implement appropriate practices to address stormwater runoff concerns. Just because there are a suite of acceptable stormwater management practices in the toolbox (i.e., Design Manual) which are all promoted to provide some water quality benefits, it's still important to conduct a thorough site evaluation and determine which practices may be most conducive to functioning appropriately for that particular site situation.

When planning and evaluating which stormwater management practices are most appropriate to use, it's also important to develop a water budget for the site, especially in locations where rainfall exceeds evapotranspiration. Much effort is often given to evaluate the expected quantity of stormwater runoff for a given type of storm event (i.e, 2-Year, 24-Hour), but this information alone is inadequate to plan and quantify the overall hydrological functioning of the site. For this particular site, the annual rainfall typically exceeds the turfgrass evapotranspiration by the order of two to one, so even the permeable soil areas will have excess infiltration recharge and percolating subsoil drainage water to remove. The excess subsurface storm runoff flows laterally across the top of the bedrock until it reaches some fractures or reemerges downslope as overland flow. Diverting stormwater runoff from the impervious surfaces to the permeable soil areas will thus further exasperate this shallow groundwater recharge and movement, especially where the subsoil is less permeable or is shallow to bedrock. These latter conditions can create additional subsoil drainage problems whereby this excess water enters the building foundation and destabilizes the integrity of the parking lot. As a result, the site characteristics at this particular site limit and provide additional challenges for implementing infiltration basins or even rain gardens; and in this case, a subsurface drain within the rain garden would still be necessary to prevent complete saturation of the rain garden soils and overland flow. The subsurface drain(s) would have to discharge to the wet pond and eventually off-site and to the stream. On the other hand, the results from the water budget suggest the temporary storage of stormwater runoff water and a wider redistribution of smaller amounts to the permeable soil areas as the soils dry during the summer can facilitate a little more on-site water removal via evapotranspiration. It was determined that about three inches of the excess annual precipitation could be removed on-site by storing this runoff, and applying it to the rain garden or turfgrass areas during the summer months to keep the soil well watered and optimizing the evapotranspiration.

Student Support and Participation:

Anna A. Royem, an MS student in the Department of Biological and Environmental Engineering (Graduate Field in Department of Natural Resources) was partially supported by the project.

The following students also participated in the Departments of Biological and Environmental Engineering (BEE 4740) and Landscape Architecture (LA 6020) design classes: Zachary M. Boggs; Maureen Bolton; Maria I. Calderon; Kelly S. Coulon; Allison G. Danner; Eden B. Gallanter; Adam C. Ganser; Christian A. Gruber; Sujung Ham; Christopher R. Hardy; Christopher Horton; Christopher G. Keil; Jee Sung Kim; Rachel T. Kunreuther; Christopher L. Mateo; Rachael P. McClure; Danielle C. Musa; Ivana B. Nitzova; Lee M. Pouliot; Matthew M. Robinson; Zachary D. Rood; Matthew S. Russell; Adam G. Silbert; Tomoki Takebayashi; Danyun Wang; and Nigel J. Watt II.

Publications and Presentations:

Calderon, M.I., Horton, C., Kim, J.S., Russel, M. and T. Takebayashi. 2009. Educational Rain Gardens: Re-Imagining the Department of Environmental Controls Site through Rain gardens on the Consumer Level. BEE 4740 and LA 6020 final class report and presentation. Department of Biological and Environmental Engineering, Cornell University, Ithaca, N.Y.

Danner, A., Hardy, C., Coulon, K., Kunreuther, R., and Z. Boggs. 2009. Tributaries – A Watershed Moment for the DEC. BEE 4740 and LA 6020 final class report and presentation. Department of Biological and Environmental Engineering, Cornell University, Ithaca, N.Y.

Keil, C., Musa, D., Silbert, A, Ham, S.J., Gallanter, E., and L.M. Pouliot. 2009. Stormwater Management Plan for NYS Department of Environmental Conservation Region 3 Headquarters. BEE 4740 and LA 6020 final class report and presentation. Department of Biological and Environmental Engineering, Cornell University, Ithaca, N.Y.

Nitzova, I., McClure, R., Mateo, C., Ganser, A., and C. Gruber. 2009. Demonstrative Rain Garden Design at the DEC Site. BEE 4740 and LA 6020 final class report and presentation. Department of Biological and Environmental Engineering, Cornell University, Ithaca, N.Y.

Rood, Z., Wang, D., Watt, N., Bolton, M., and M. Robinson. 2009. The Oxbow DEC Rain Garden – New Paltz, NY. BEE 4740 and LA 6020 final class report and presentation. Department of Biological and Environmental Engineering, Cornell University, Ithaca, N.Y.

Other Collaborations and Opportunities:

Other project collaborations included Fran Dunwell and Barbara Kendall, NYS Department of Environmental Conservation, Hudson River Estuary Program (HREP); Peter Trowbridge, Cornell LA; John Sanderson, Director, Development Related Outreach Program for Sustainability (DROPS) initiative; and several NYS DEC Region 3 staff. An opportunity that has evolved from this work is that considerable interest on behalf of conservationists, engineers, and practitioners has been generated regarding the appropriate design and application of rain gardens for both urban and agricultural stormwater runoff settings. There are efforts now underway to develop a Code of Practice Standard for the design and use of rain gardens to remediate stormwater runoff quantity and quality.

Investigation of roadside ditches as contributors to in-stream bank erosion, suspended sediment loads, and degraded water quality across New York

Basic Information

Title:	Investigation of roadside ditches as contributors to in-stream bank erosion, suspended sediment loads, and degraded water quality across New York
Project Number:	2009NY120B
Start Date:	3/1/2009
End Date:	2/28/2010
Funding Source:	104B
Congressional District:	22
Research Category:	Water Quality
Focus Category:	Water Quality, Floods, Surface Water
Descriptors:	None
Principal Investigators:	Rebecca Schneider

Publications

There are no publications.

Investigation of Roadside Ditches as Drivers of Stream Geomorphological Processes in central New York

Rebecca Schneider

Dept. Natural Resources

Final Report

14 May 2010

Problem Statement

Issues of non-point source pollution and suspended sediment are receiving attention nation-wide as these factors degrade drinking water quality and impact already scarce water resources. For the past several decades there has been a strong focus on streambank restoration as one solution to help reduce erosion and sediment loads. The federally-funded Conservation Reserve Program has spent millions on restoration of stream riparian habitats on agricultural properties, but with mixed success. The Chesapeake Bay Program has recently been criticized for lacking tangible evidence of sediment reduction despite its efforts to restore thousands of miles of streamsides throughout its watershed (http://www.chesapeakebay.net/newsassessment041807.htm). These findings highlight the need for an improved understanding of the mechanistic processes that control sediment movement out of watersheds and through stream channel systems.

Land use patterns play a major role in the drainage system and control the rate and amounts of water and materials that runoff to the streams. Clearing of vegetation, compacted soils, and decreases in organic matter content all reduce the landscape's capacity for rainfall infiltration and increase surface runoff. Most recently, impervious surfaces have been recognized as major contributors to stormwater runoff (Allan 2004; Brabec et al. 2002; Arnold and Gibbons 1996). Although limited in number, studies relating impervious cover to stream health consistently show that having only ~10-15 % of a watershed covered by impervious surface results in an increase in the magnitude and frequency of floods (Meyer et al. 2004, 2005; Miltner et al. 2004; Booth1998), a reduction in base flow (Rose 2002; Schueler 1994), degraded aquatic habitat (Hatt et al. 2004; Wang et al. 2003; Wang and Kanehl 2003), and decreases in biodiversity (Helms et al. 2005; King et al. 2005; Fitzpatrick et al. 2004). A few of these studies suggest that it is the connected impervious surface that seems to be the critical factor (Jones et al. 2000; Forman and Alexander 1998). In response to these studies, EPA implemented Phase II of its Stormwater Regulations in 2003 as an effort to reduce nonpoint source runoff emanating from small towns nation-wide.

Much of the research on stream erosion and geomorphic processes has focused within the stream channel itself. Beginning with early work in the 1960's, Wolman and colleagues identified effective discharge as the key to channel formation, and specifically the importance of bankfull flows that reoccur approximately once per two years (Emmet and Wolman, 2001, Wolman and Miller, 1960). Channel geometry and morphology result from the sediment transport process, which in turn is driven

in part by topographic slope and geology (Church 2006). In many systems, sediment erosion is derived primarily from stream channel banks (Trimble 1997). Schumm laid out the framework for critical thresholds in geomorphology, above which sediment movement and channel reformation are initiated (Schumm 1979) and Larsen and co-workers (2006) demonstrated that lateral stream migration was associated with stream power above critical threshold values. Although historically stream geomorphology has been considered as a uni-directional process, in that flow and energy determine plant community composition, this perspective has shifted as research is demonstrating that riparian vegetation provides a strong counter-acting influence on erosion, increasing stabilization and controlling channel formation in both single channel and multi-channel systems (Simon and Collison 2004; Tal et al. 2004; Gran and Paola 2001).

Within this framework, the influence of the network of roadside ditches has been almost totally overlooked. Ditches are the artificially created depressions that parallel both sides of most roadways and have been used for almost a century as the primary tool for draining road surfaces during storms. Ditches are constructed and maintained annually by local highway department staff, who are usually left out of stakeholder discussions concerning water resource management, water quality, and stream health. Research has considered agricultural drainage systems (Dukes and Evans 2006; Bouldin et al 2004) as contributors to water quality degradation and the impact of logging roads has similarly been evaluated (Wemple et al. 1996). Impacts of roads have been considered in the context of landscape fragmentation, invasives and other ecological impacts (Foreman and Alexander 1998). However surprisingly, the specific contribution of roadside ditches to stream geomorphic processes has thus far been overlooked. **This project will investigate, for the first time, the role of roadside ditches as drivers of in-stream bank erosion, increased sediment loading, and degraded water quality.**

For the past several years, I have been leading a team in an integrated research and extension project documenting the impacts of roadside ditches. The results of this research indicate that roadside ditches significantly alter the natural drainage networks and hydrologic processes within watersheds in multiple ways:

- roadside ditches increased the effective stream channel density by two fold or greater (ex. Enfield Creek, Tompkins Co. - 140 km ditches; 70% connected to streams, stream channel density increased from 1.6 to 4.2 km^{-1}) ;
- the majority of the roadside ditches in these rural watersheds discharge directly into headwaters, e.g. 1st and 2nd order or ephemeral streams;
- significant quantities of gravel, cobble, and other bedload (e.g. avg ~ 0.1 - 2 kg/ditch-storm with maximum of 4 m^3 during a 10 cm rainfall event) are deposited as deltas along the stream channel at ditch outfalls;
- ditches intercepted~20% of the shallow runoff from the entire Doolittle Cr. watershed (Tioga Co.) surface, and rapidly shunted it farther downstream where it was discharged as a series of high velocity, point sources, like faucets, into the stream flow;
- ditches scraped and left exposed, or which become incised by high water velocities, were a major source of suspended sediment and dissolved chemicals to the downstream waters (avg. TSS concentration 2-5 mg/l, maximum 35 mg/l),
- ditch contributions of runoff lead to an increase in peak stream stormwater flows and decreased baseflows;
- ditches are a rapid conduit and reservoir of *E.coli* and other pathogens from manure spread on fields to downstream public water supplies.

Research Hypotheses and Objectives:

As of result of our work thus far, we hypothesize that chronic ditch outflows are additionally playing a major, but unrecognized role, in the restructuring of stream channel systems, causing them to be in dynamic disequilibrium and leading to erosion, sediment movement, and degraded water quality throughout NY and the Northeast. Specifically, we hypothesize that the deltas formed of ditch bedload and deposited at non-natural locations in the stream cause the rerouting of stream flow with associated erosion of the opposite streambank, and simultaneously, point outflows from ditches have high velocities and discharges during storms (e.g. faucets) that initiate a process of erosion and deposition in the stream associated with the ditch outfall. The combined influence of both ditch deltas and faucets leads to subsequent downstream re - equilibration of the stream channel, with sediment deposition and scouring cycles that alter the longitudinal sinuosity and channel bed configuration from their natural patterns. **Our overall goals were to test these hypotheses and investigate the influence of roadside ditches on stream erosion processes**

Study Sites

The study was conducted in the Doolittle Creek watershed located near Candor, NY in Central New York. The watershed is one of the headwaters to the greater Susquehanna River basin and therefore contributes to environmental conditions in the downstream system. The Doolittle Creek Watershed spans roughly 40 km^2 and overall land use is approximately 50% forested, 40% pasture and cropland, and 10% residential. The area receives, on average, roughly 980 mm of precipitation annually and the annual temperature ranges from 0.5°C to 14°C (Northeast Regional Climate Center). Stream sites were chosen based on a map of ditch-stream interfaces within the Doolittle Creek watershed located during our previous studies.

Methods

In order to evaluate the effects of the ditches on the streams, the approach used was to compare the geomorphological features of a 30 m reach above the stream-ditch interface with a 30 m reach below the interface at six different stream sites (Figure 1). All were 1st order streams, with no other ditch contributions up-stream. The 30 m length was selected as being of sufficient length to capture at least one complete S-wave in the stream's longitudinal sinuosity and each study reach was located approximately 20 m above and below the stream-ditch interface. Four different aspects of in-stream geomorphology were recorded for field measurements at each reach: cross-sectional profile, longitudinal profile, grain size analysis, and bank scour. The cross-sectional profile and grain size analysis were also conducted at the stream-ditch interface. The longitudinal and cross sectional profiles were surveyed using surveyor's equipment that included a transit, tripod, compass, meter tape, and stadia rod.

Cross-sectional profiles were captured by recording the elevation changes along six transects, perpendicular to the direction of streamflow. Transects were specifically located to intercept three pools and three riffles, alternating between types, from endpoint to endpoint of the 30 m reach. For each cross-section, at least 14 points were recorded to capture the shape of the stream. The left and right bankfull edges were recorded for each profile, bankfull left always located at the two m mark along the transect. If possible, each transect extended at least two meters into the floodplain on both banks. Several in-stream points of geomorphic relevance were recorded and are described as follows: (a) the wetted edges, or where the water perimeter, if flowing, was located along each bank; (b) the midpoint of the stream defined as the midpoint between the bankfull points; (c) three channel measurements to

the left and right of the midpoint; (d) and the thalweg. Additional points were recorded where significant changes in the slope of the streambed occurred.

The cross-sectional profile data were summarized into three analyses: average width and depth, and bankfull flow. The measured stream bankfull widths were calculated by taking the difference between the two determined bankfull points from the cross-sectional profiles. Stream depth was calculated by subtracting the average of the bankfull depths from the thalweg depth. Both width and depth data were summarized based on their location up and downstream and whether the profile was a pool or riffle. Using an idealized triangular channel model of the streams, bankfull flow was calculated according to Manning's equation. The cross-sectional area, A, was determined from the area of a triangle with the base and height value being the width and depth of the streams, respectively. Hydraulic radius was calculated from the triangular area and the wetted perimeter of the recorded data points. Channel slope was calculated by taking the average change in depth between each cross-sectional profile. The same roughness coefficient was used for the up and downstream bankfull flow calculations. A T-test analysis was used to compare upstream vs downstream reaches for each parameter.

The **grain size analysis** was conducted following the "step-toe method" described in the USDA Stream Channel Reference Sites (1994). The method was slightly modified by counting an average 115 grains at multiple transects located randomly within each stream reach. At each transect a grain was measured along its intermediate length axis at 10 cm intervals from bankfull right to left. The larger grains were measured with a ruler and the smaller grains with a digital caliper. Sediment grains smaller than 1 mm were not measured but were recorded as "silt/clay".

In order to summarize the grain size analysis data, the counted pebbles were tallied per size class and their percent total of the counted pebbles was determined. Using the percent total values, the average grain size distribution for the upstream reaches, downstream reaches, and all ditch-stream interfaces were graphed and compared statistically using Chi-Squared Analyses.

Stream bank scour was measured by recording the total length of scour (in meters) on each bank based on a 1-4 ordinal ranking system: 1-no scour, 2-light scour with vegetation, 3-steep cut bank with remaining vegetation, 4- steep cut bank with no vegetation. Cumulative scour per category from both left and right banks within each reach were summarized. Along the stream banks, the length of each segment of scour was recorded.

In order to capture **the longitudinal profile**, the angle, elevation, and distance from the transit to the thalweg of the stream were recorded. The thalweg is the deepest channel in the stream, generated by the fastest flow. Before surveying, the thalweg was mapped with flags to pre-determine the points to record. Each flag was placed roughly 1-2 m apart depending on how frequently the thalweg changed direction and at <1 m intervals if an abrupt change in thalweg direction was observed. The thalweg was then surveyed based on the flagged points. The angles recorded were relative to true north. Survey measurements were made to the nearest 0.001 m.

The longitudinal profile data were evaluated by converting the distance and angles recorded into Cartesian coordinates. Using the X and Y values, the distances between the points were calculated and summed to find the in-stream length. To calculate the sinuosity for the six streams, the in-stream length was then divided by the 30 m standardized distance. (The downstream reach of Stream 6 was only 22 m long and so the sinuosity was calculated using that length.) Wavelength and amplitude of

each reach were also calculated. A T-test analysis, using Excel Data Analysis tool, was used to evaluate differences between the upstream and downstream reaches on each parameter.

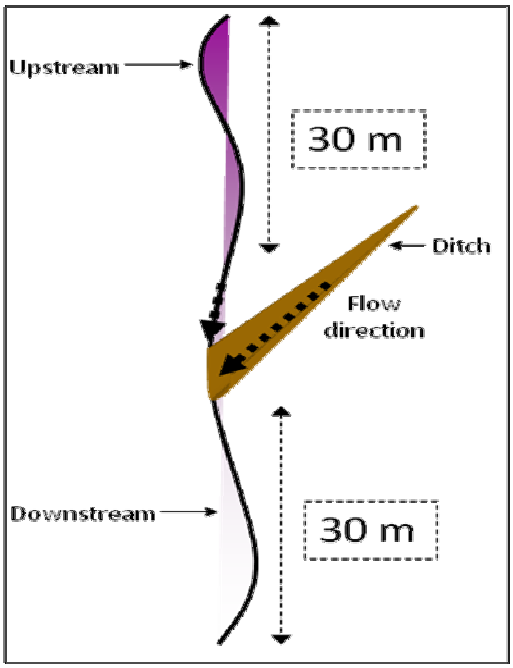


Fig.1 Schematic of sampling design used to evaluate ditch impacts by comparing reaches upstream and downstream of the ditch confluence.

Principle Findings and Significance

Cross-sectional Channel Profiles

Both the average width (Fig. 2) and the average depth (Fig. 3) exhibited a borderline significant trend ($n = 5$, $P_W = 0.11$, $P_D = 0.16$) of increasing width and depth in the downstream as compared to the upstream segments. The downstream reach of Stream 5 was not measurable because the channel was only 10 m long before opening up into a marshland. Of the six streams studied, Stream 6 is the only system which decreased in width and depth because the downstream channel is disconnected from the upstream by two ditches which diverted water to the nearby property's man-made pond. Although the change in width:depth ratio (W/D) was statistically non-significant ($n = 5$, $P_{W/D} = 0.37$), the W/D of Streams 1, 2, and 6 decrease suggesting incision of the stream channel. In contrast, W/D of Streams 3 and 4 increase suggesting broadening of the stream channel.

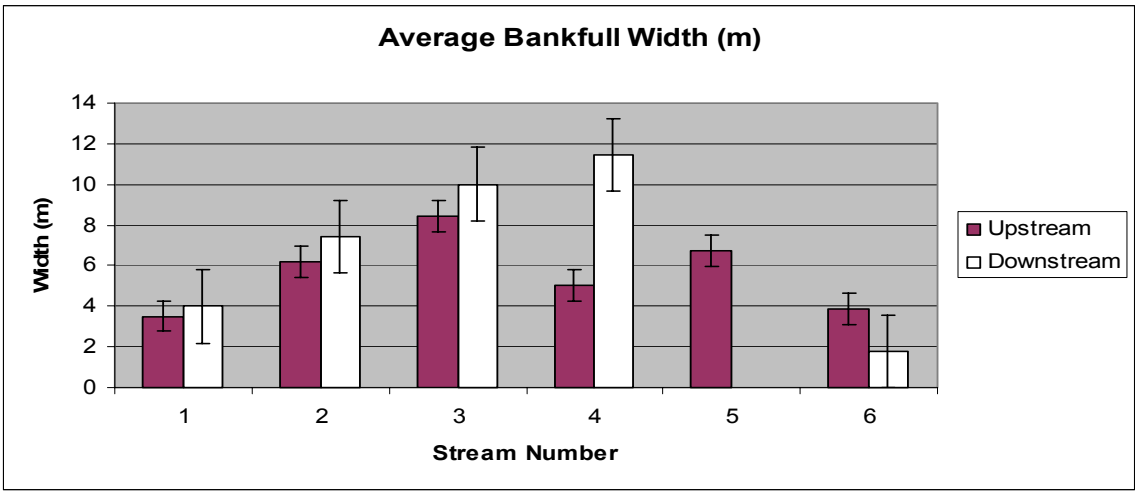


Figure 2. Average Bankfull Width

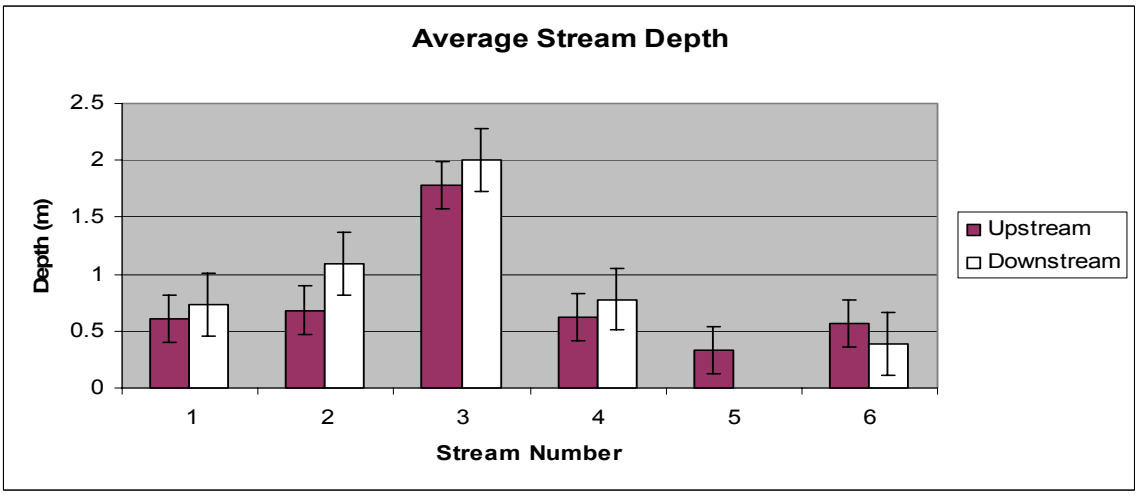


Figure 3. Average Stream Depths

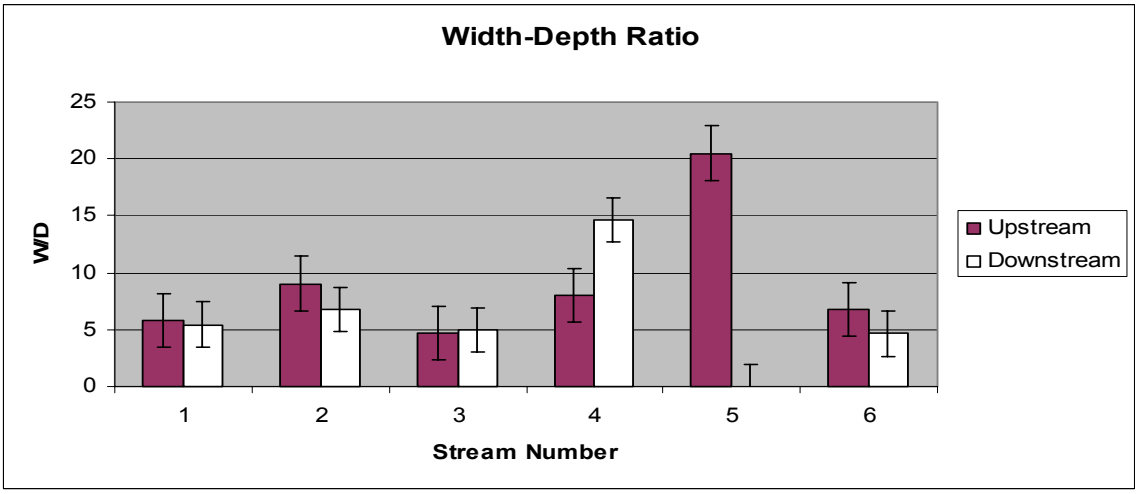


Figure 4. Average Width to Depth Ratio

Modeled Bankfull Flow

The modeled bankfull flow (Fig. 5) exhibited a consistent but non-significant (n = 5, $P_F = 0.18$) increase in the downstream as compared to the upstream reaches. Stream 6 demonstrated a decrease in flow downstream resulting from the reduction of stream size and the diversion to the neighboring pond. Average channel slope (Fig. 6) exhibited a consistent but non-significant (n = 6, $P_{Slope} = 0.32$) decrease in the downstream.

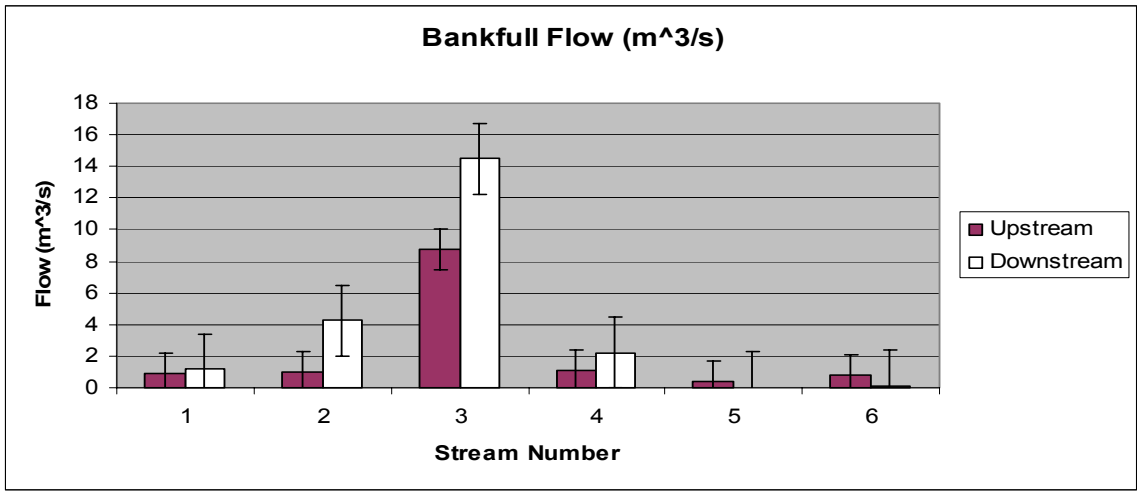


Figure 5. Average Bankfull Flow

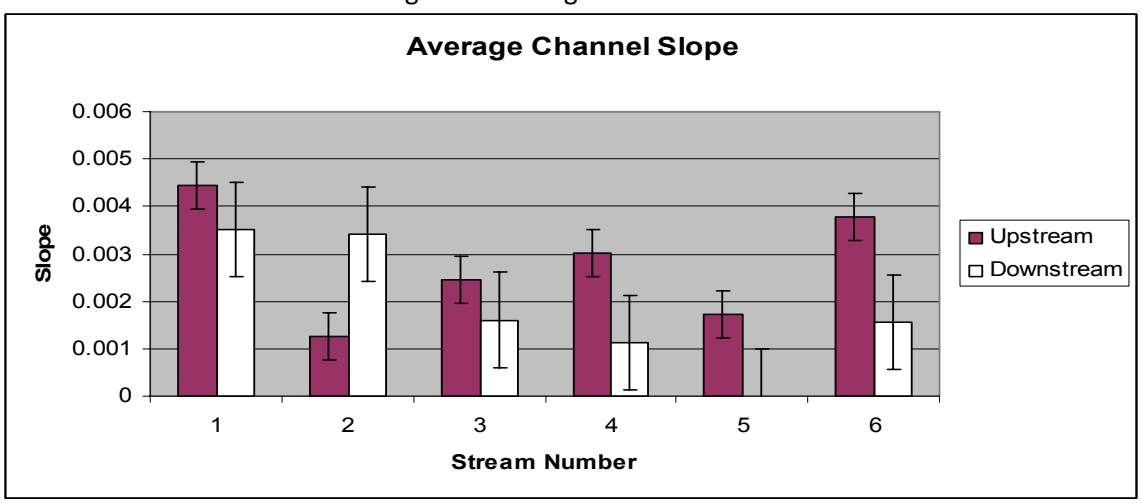


Figure 6. Average Channel Slope

Grain Size Analysis

Chi-squared analysis of the average grain size distribution patterns in the upstream versus downstream reaches identified a significant (n = 6, $P_{Gr} \leq 0.05$) shift in the 16-64mm grain sizes. Average grain size distribution (Fig. 7, 8) indicates that the majority of the grain sizes are ≤ 2mm and 32-256mm in the upstream reaches whereas it is ≤ 2mm and 16-64mm in the downstream. That is, there is a downward shift towards smaller grain sizes in the downstream reaches. The grain sizes of the deltas formed at the ditch-stream interface are predominantly ≤ 2mm and 32-64mm, comparable to that of the grain sizes in the downstream reach.

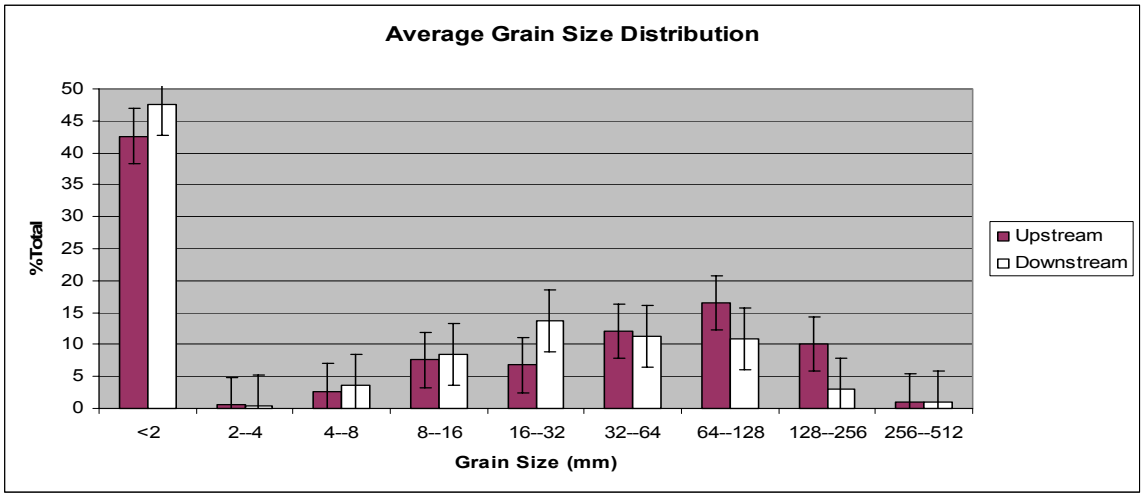


Figure 7. Average Grain Size Distributions in upstream vs downstream reaches

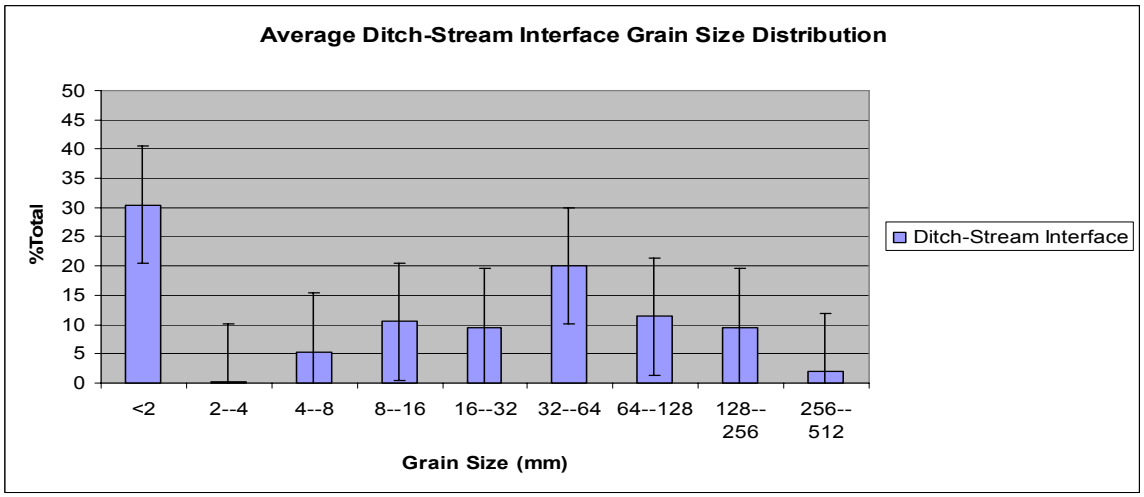


Figure 8. Average Ditch-Stream Interface Grain Size Distributions

Bank Scour Distribution

The Chi-Squared (X^2) analysis reveals a significant ($n = 6$, $df = 3$, $P_{Scour} \leq 0.05$) deviation from the upstream scour profile such that there is greater proportion of steep cut and bare bank scour (category 4) types in the downstream reaches (Fig. 9). The intermediate scour types occur less in the downstream reaches.

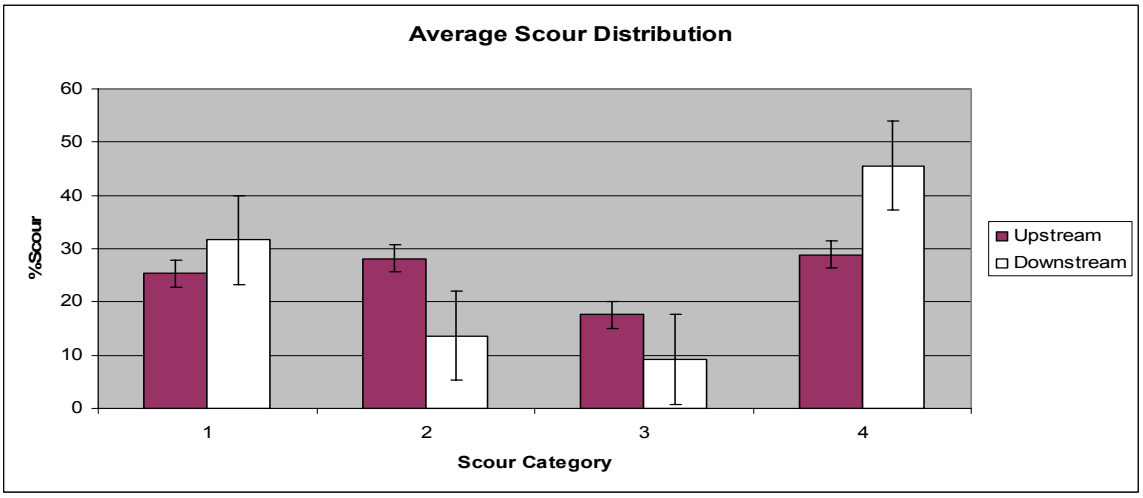


Figure 9. Average Percent Scour

Longitudinal Profile Characteristics

Wavelength and amplitude (Fig. 10, 11) exhibit a consistent increasing trend in the downstream reaches (although non-significant; n = 6, P_W = .09, P_A = 0.11). Average sinuosity exhibited no consistent pattern between upstream and downstream reaches (Fig. 12, n = 6, P_{Sin} = 0.33). The observed increase in sinuosity in Stream 6 may be the result of the alteration to the headwaters of the man made pond.

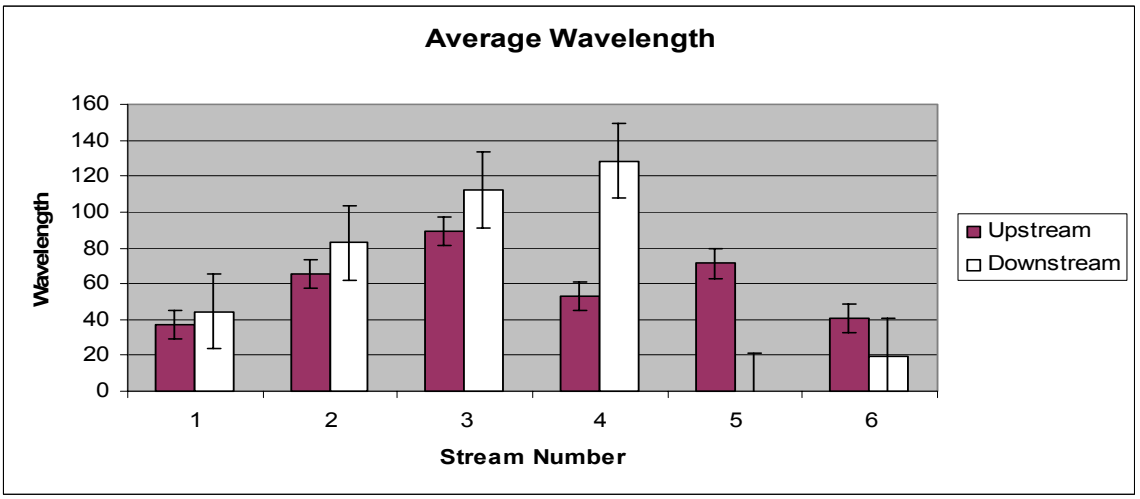


Figure 10. Average Wavelength

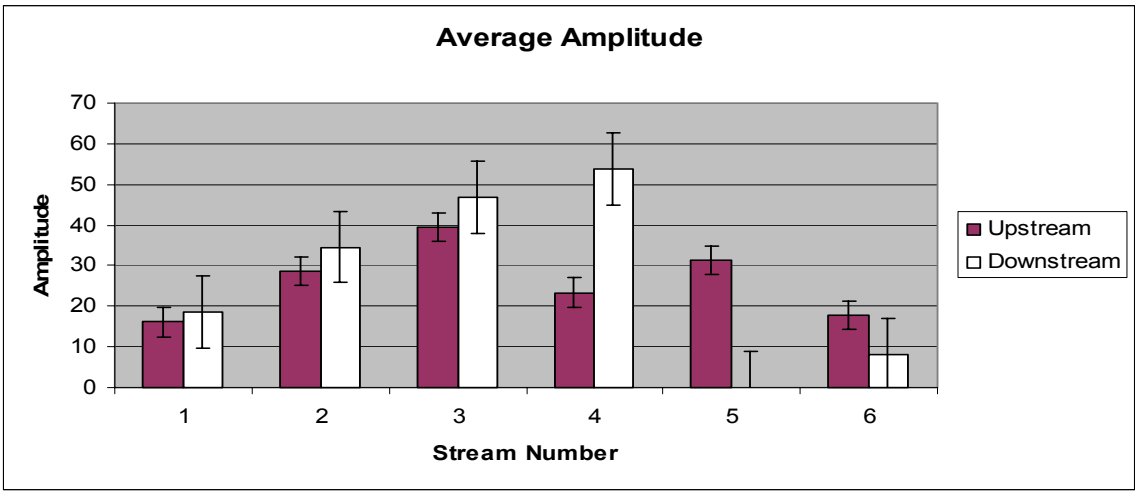


Figure 11. Average Amplitude

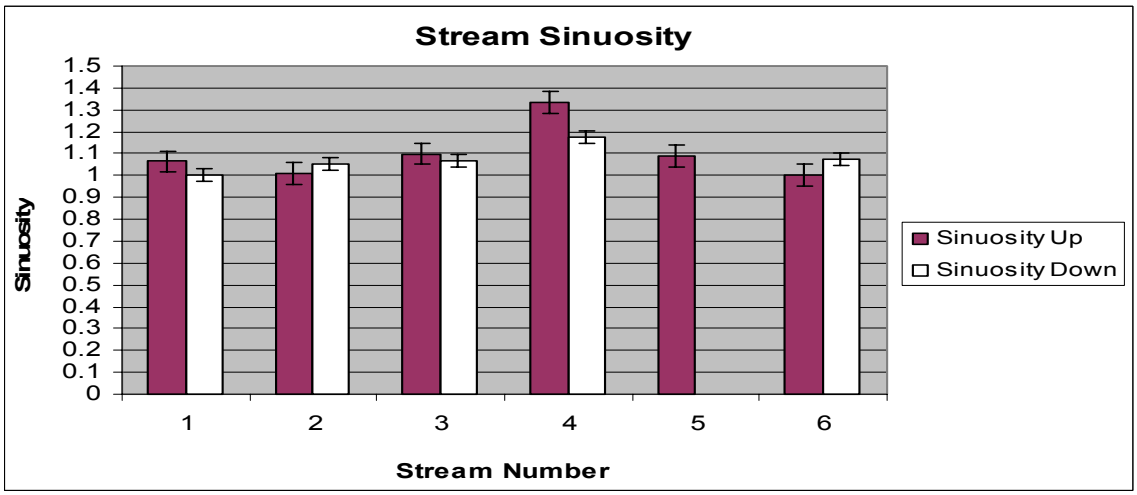


Figure 12. Average Stream Sinuosity

Conclusions

Overall, this project provides the first, preliminary evidence reported that roadside ditches are influencing geomorphological processes in headwater streams in a central NY watershed. The sample size of streams examined was small, six in total but only 5 for certain variables. Nonetheless, we documented a weakly significant increase in overall amplitude, as well as a consistent trend of increasing cross-sectional width and wavelength in the downstream as compared with the upstream reaches. Such changes in stream cross-sectional and longitudinal profiles result logically from a physical process whereby ditches intercept and contribute greater volumes of water to the stream at a given point than would be there by natural runoff processes. The comparison of modeled bankfull flows supports this interpretation.

This study also documented a decrease in the average grain size distribution of the substrate in the downstream reaches. The altered grain size pattern is similar to that of the grain sizes found in the deltas formed at the ditch outfalls. This material is transported as bedload, and sometimes in suspension, from the ditches during storms, and deposited as a delta within the stream. Our previous study documented that the bedload in ditches is made up in large part of the gravel placed along the

road shoulders as part of road management and which is routinely re-applied as the gravel disappears into the ditch (Dias-Robles, 2007). However, these changes in sediment texture are likely to impact aquatic insects and other biological components of the stream ecology.

Finally, we documented a significant increase in the extent of streambank scour and exposed soil in the reach downstream of the ditch –stream interface. This exposed bank can be a source of erosion and sediment transport during storms and thereby contributes to degraded water quality downstream.

This study represents our first efforts to document ditch impacts on stream geomorphology. The results will form the basis of a grant proposal to allow a more comprehensive examination, i.e. to include a greater number of stream reaches, to evaluate impacts farther downstream from the ditch-stream interface, and to include quantitative data on ditch "watersheds" and discharge.

Student Support

Two undergraduate students, J. Kimchi and H. Knowlton, conducted much of the field work and data summarization for this project. J.Kimchi used the project as the basis for his honor's thesis in Cornell's Dept. of the Science of Natural Earth Systems.

Presentations

Kimchi, J., R. Schneider, and H. Knowlton. Dec. 2009. Dept. of Natural Resources – Annual Undergraduate Symposium, Cornell, Ithaca, NY

Kimchi, J. and R. Schneider. May 2010. Dept. of Natural Resources – Annual Honor's Symposium., Cornell, Ithaca, NY

Associated Opportunities or Collaborations

The findings from this research have been presented as part of a more comprehensive roadside ditch outreach program to the NYS Dept. of Transporation's statewide drainage committee.

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The fate of non point sources of nitrate in lawn maintenance

Basic Information

Title:	The fate of non point sources of nitrate in lawn maintenance
Project Number:	2009NY121B
Start Date:	6/1/2009
End Date:	2/28/2010
Funding Source:	104B
Congressional District:	1
Research Category:	Water Quality
Focus Category:	Nitrate Contamination, Non Point Pollution, Water Quality
Descriptors:	None
Principal Investigators:	Gilbert Hanson, Henry J Bokuniewicz

Publications

There are no publications.

Project Report May, 2010

The Fate of Non-Point Sources of Nitrate in Lawn Maintenance

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Department of Geosciences
Stony Brook University
Stony Brook, New York

INTRODUCTION

Quantifying nitrate leaching from fertilizer practices of turfgrass lawns is essential to keep concentrations in groundwater below the U.S. Environmental Protection Agency drinking water standard of 10 mg/L especially in areas served by septic tanks (Baier and Rykbost, 1976; Porter, 1980; Flipse and Bonner, 1985; Flipse et al., 1984; Kimmel, 1984). Concentrations of N-NO^3 in soil water leachate are commonly less than 5 mg/L beneath fertilized turf (Petrovic, 1990), however, under certain conditions, concentrations can reach 40 mg/L (Frank et al., 2006; Guillard and Kopp, 2004). Recently established plots of mixed grass species, for example, might leach ten times more nitrate than did areas planted with homogenous grass (Erickson et al., 2001). On Long Island, NY the potential for nitrate leaching to the groundwater is particularly high due to the sandy soils and the large volume of infiltration from rain and irrigation sprinklers. Twenty-five percent of the land has been classified as turfgrass (Koppelman, 1978) **t**he Suffolk County Water Authority estimates that 73 billion liters annually (30%) of the annual water consumption in Suffolk County is used for irrigation. In addition, about half of the 112.2 cm of precipitation received each year infiltrates to the groundwater (Busciolano, 2004).

"More studies are needed to determine the fate and transport of N-NO^3 applied to turf in urban or suburban settings" (Guillard and Koop (2004) including multiyear investigation of slow-release, nitrogen fertilizers and for more leaching studies using different sources of nitrogen (Petrovic, 1993). Such long-term monitoring studies can define the interannual variability. Investigations elsewhere are, of course, useful but regional conditions and practices need to be examined to determine the impact to groundwater reserves (Petrovic, 1990).

PREVIOUS WORK

Porter (1978;1980), conducted a field survey to evaluate the impact of lawn fertilizer to groundwater in urban areas of Nassau and Suffolk County, NY. The sites received ammonium nitrate-nitrogen fertilizer, a fertilizer no longer commonly used because of environmental concerns and a preference for slow-release forms of nitrogen. Just below the root zone, concentrations as high as 32.5 mg/L were found. From such data, Porter (1978) calculated that fertilizers applied to recreational lawns are estimated to contribute between 29-35% of the nitrogen load to Long Island aquifers.

In 2001, studies were begun on Long Island to measure nitrate concentrations beneath urban lawns that are fertilized with either organic or chemical fertilizers (Schuchman 2001, Munster 2008). Samples were also taken below unfertilized turf and in a forest setting. Soil water nitrate concentrations were collected below the turfgrass root zone from ceramic suction lysimeters at depths of 60 cm, 80 cm, 100 cm and either 120 or 150 cm. Sites were chosen to represent a diverse range of conditions across Suffolk County. Site conditions and fertilizer treatments varied indicative of natural conditions because homeowners and landscapers will not always fertilize in the same way from year to year. By 2003, measurements were being made beneath eight turfgrass sites. Higher average $N\text{-}NO^3$ concentrations measured under the plots treated with chemical fertilizer (14 ± 3 mg/L) than the plots treated with organic fertilizer (6.2 ± 1.1) perhaps due to excess applications of chemical fertilizer (Munster, 2008).

METHODS

Observations were made at three of the original eight sites in 2007. These were Oakdale (an organically fertilized site at 40 44’ 54.40”N; 73 08' 16.67"W and chemically fertilized site at 40 ^{o} 44' 53.92"N; 73 ^{o} 08' 10.35"W); Hauppauge (40 ^{o} 48' 27.74"N; 73 ^{o} 15' 06.38"W) and Huntington (40 ^{o} 52' 08.95"N; 73° 25 '03.77"W). The instrumentation at Huntington was lost at the end of 2008, but measurements were continued monthly at the other two sites through 2009. The Huntington organically fertilized site was 280 m^2 directly adjacent to the chemically fertilized site which is 330 m^2. The Oakdale organically fertilized site was in a 510 m^2 lawn surrounded by a parking lot and roads. The Oakdale chemically fertilized site and an additional organically fertilized site were about 30 meters away. The chemically fertilized site is rectangular, 665 m^2, and directly adjacent to the organic site which is 225 m^2. The Hauppauge organically fertilized site was 215 m^2 and separated by a few large trees from the chemically fertilized site which covered 250 m^2.

Turfgrass at the study sites were typical of the region, such as, the Dura-Sod blend of Fescue and Bluegrass at one site as recommend by the manufacture for the Long Island area (Schuchman, 2001). Turfgrass may be intermixed with naturally occurring clovers, crabgrass, moss and other weeds. Soil type was classified according to the mapped units (Warner, 1975) and particle size was previously determined (Munster et al., 2006). The organic fertilizers were composed of natural sulfate of potash, phosphate rock, colloidal phosphate, oyster meal, kelpmeal, greensand, vegetable and animal protein meals, natural nitrate of soda, compost, and dried whey. Manure was not used.

Both sites were watered with an automatic sprinkler system twice per week providing infiltration between 3.8 and 5.1 cm per week (www.scwa.com, Oral communication Michael DeBlasi, SCWA, August 2004). The sites are mowed between April and November and the clippings are not removed. Soil water samples from lysimeters were taken monthly, filtered in the field, stored in acid-rinsed polypropylene bottles and, once in the laboratory, frozen (-10ºC) until analyzed. On average 250 mL were collected but sample volume ranged from 5 to 450 mL. Concentrations of $N\text{-}NO^2$, NH^4 and $N\text{-}NO^3$ were analyzed at the School of Marine and Atmospheric Sciences at Stony Brook University on a Lachat’s QuickChem8500 Flow Injection Analysis System using

Lachat's Method 10-107-04-1-J. Five to ten milliliters of sample are needed for analysis. These analyses have an uncertainty of 5% determined by anonymous standards and duplicate analysis. Detection limits were 0.1 mg/L for all ions. Nitrite and ammonium were rarely detected in the soil water samples.

RESULTS

Table 1 Summary of soil water N-NO3 concentrations at 100 cm and for bulk precipitation.

Year	n	Avg.	StD	Max.
		Chemical		
Combined	176	9.7	12	76
2003	23	3.1	2.3	7.6
2004	23	9.9	6.7	26
2005	32	7.7	7.1	27
2006	47	12.3	14.4	76
2007	14	27.2	29.1	123.0
2008	18	23.0	19.0	81.2
2009	19	11.9	8.5	32.9
		Organic		
Combined	279	6.5	8.1	45.3
2003	53	4.8	6.0	33.3
2004	53	3.6	3.9	24.8
2005	47	6.3	6.8	31.5
2006	50	11.4	11.8	45.3
2007	23	8.0	12.5	66.1
2008	27	3.0	2.9	17.3
2009	26	5.7	9.0	57.3
		Precipitation		
2005-2009	26	5.7	9.0	13.1
		Unfertilized turf		
Combined	68	1.29	1.3	5.58
2003	9	2.44	1.58	4.74
2004	12	1.2	1.09	3.98
2005	22	0.83	0.63	2.41
2006	23	1.17	1.46	5.58
		Forest		

Combined	26	0.4	1.01	3.9
2005	10	0.11	0.08	0.26
2006	9	0.07	0.05	0.14

The data is tabulated in Table 1. Monthly nitrogen as nitrate concentrations in soil water collected at 100 cm varies throughout the study period, but both the concentrations and variability were similar to that seen at these sites between 2001 and 2006 (Figure 1a and 1b).

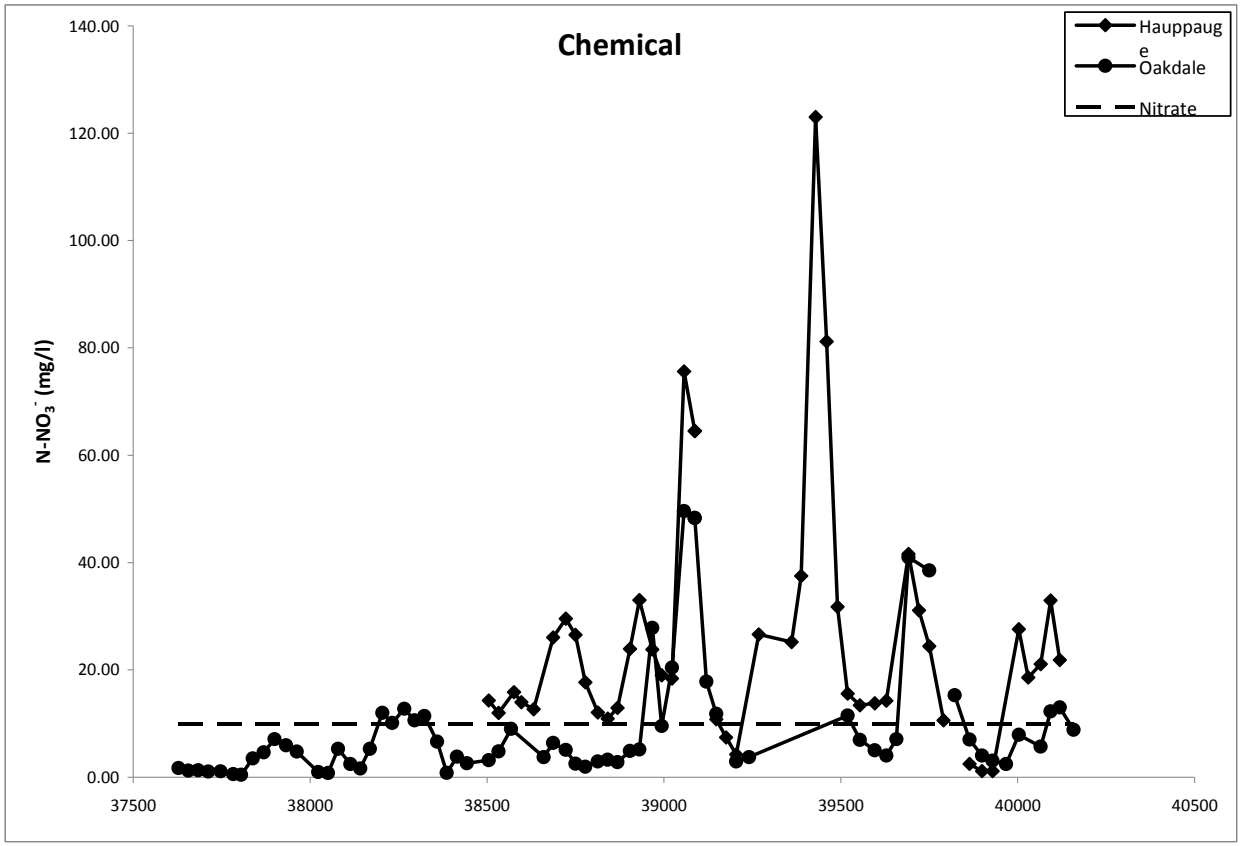

Figure 1a. Time series of nitrate concentrations in soil-water 100 cm below chemically fertilized turf.

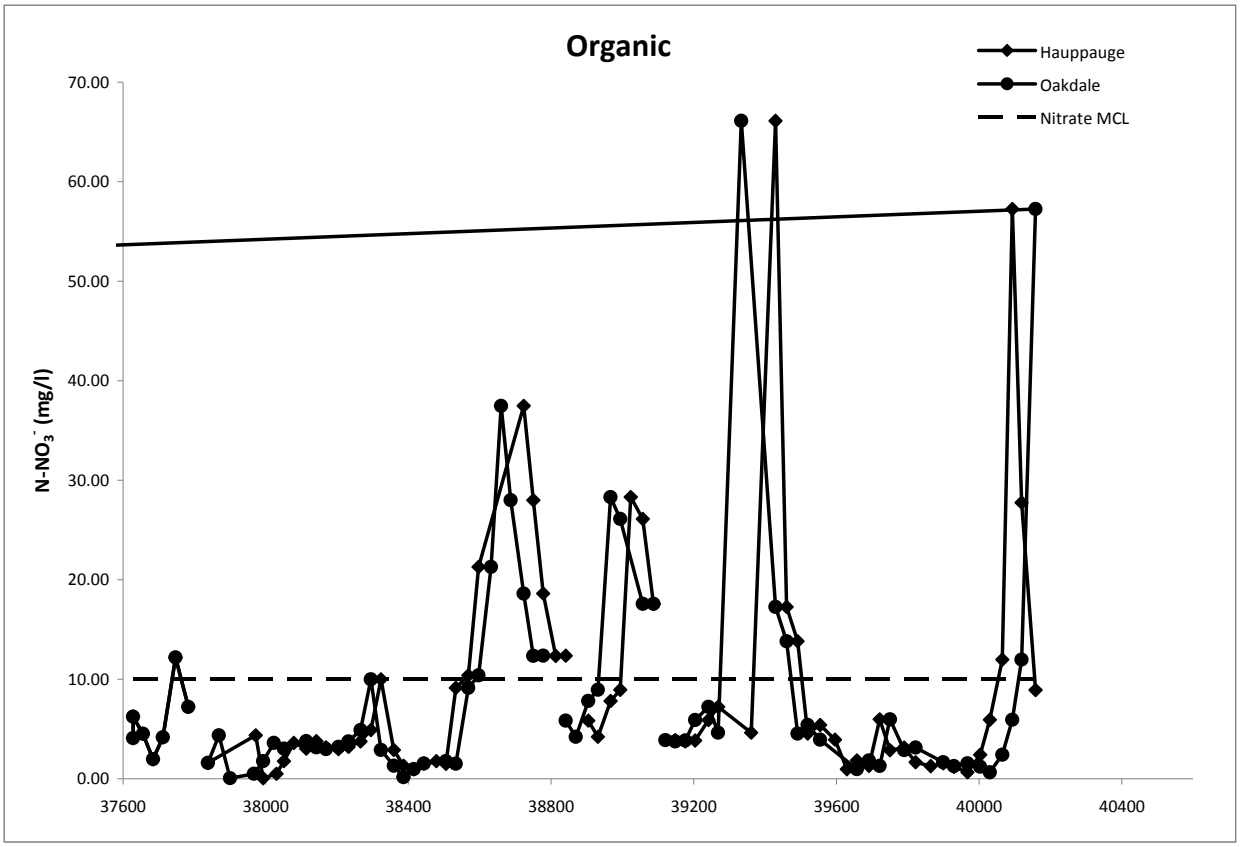

Figure 1b. Time series of nitrate concentrations in soil-water 100 cm below organically fertilized turf.

Highest concentrations were seen over the winter months (Figure 2) except in the winter of 2008-2009, when fertilization in the fall (October) was not done. The organically fertilized site at Oakdale consistently showed lower concentration than that at Hauppauge. The Oakdale site had been more recently disturbed and it may be the turf there was still in the process of maturation.

There is a difference in soil-water N-NO^3 concentrations at 100 cm, on average, between different fertilizer treatments however, there is also variability between sites that receive the same type of fertilizer. This variability could be due to variable moisture and temperature differences from year to year, although concentrations at a given site do not vary much between years or to difference in soil and hydrologic properties (Munster et. al., 2006).

The sites treated with chemical fertilizer leach, on average, more nitrate than the sites treated with organic fertilizer (Figure 3). This difference may be due to differences in site properties and not a function of fertilizer treatment, as average soil water N-NO^3 concentrations vary between sites, even between sites treated with the same type of fertilizer.

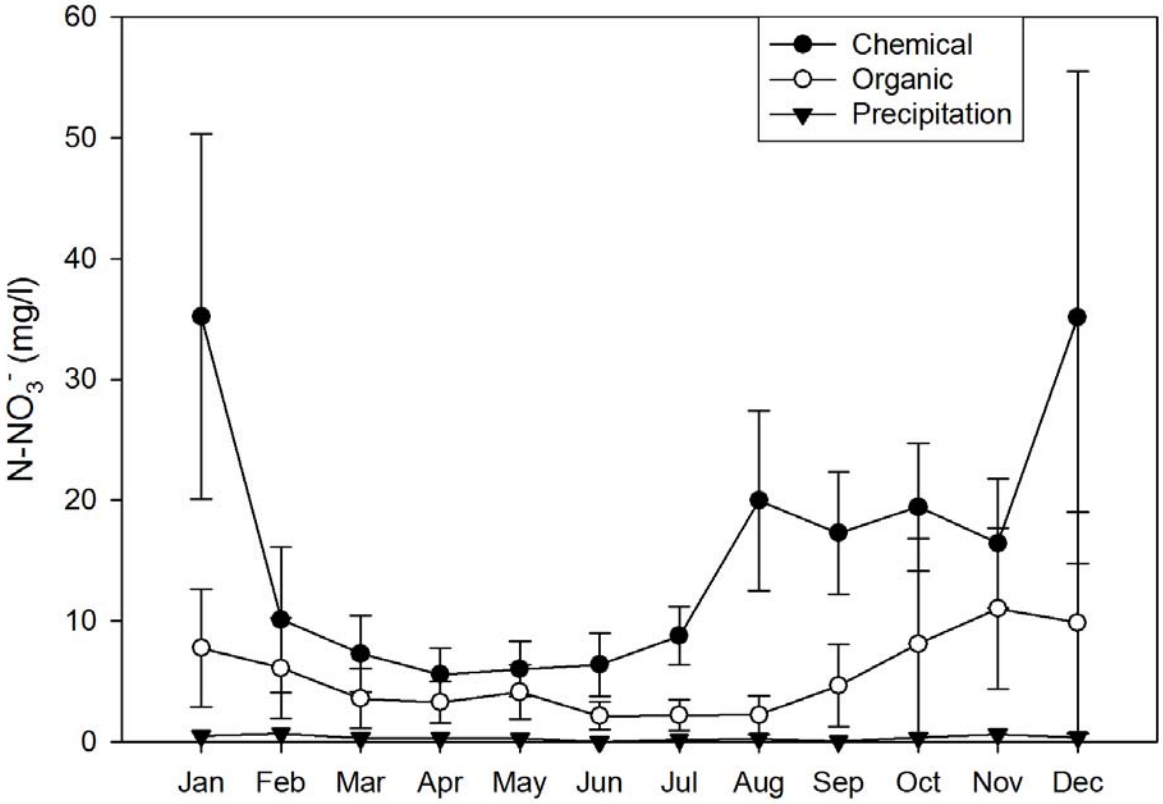

Figure 2. Average monthly N-NO^3 values of soil water collected at 100 cm from the combined years 2003-2009. Bulk precipitation collected from January 2005 to December 2009. Error bars are standard error of the mean. The regulated drinking water standard is 10 mg/L.

Higher soil water average N-NO^3 concentrations under the sites treated with chemical fertilizer than those treated with organic fertilizer could be due to higher rates of applied nitrogen at the sites treated with chemical fertilizer, although there is no direct relationship between yearly application rate and average concentrations. Even when soil and hydrologic properties are relatively constant sites fertilized with organic fertilizer can leach similar concentrations of nitrate as chemical sites even though inputs of nitrogen are less at the organic sites.

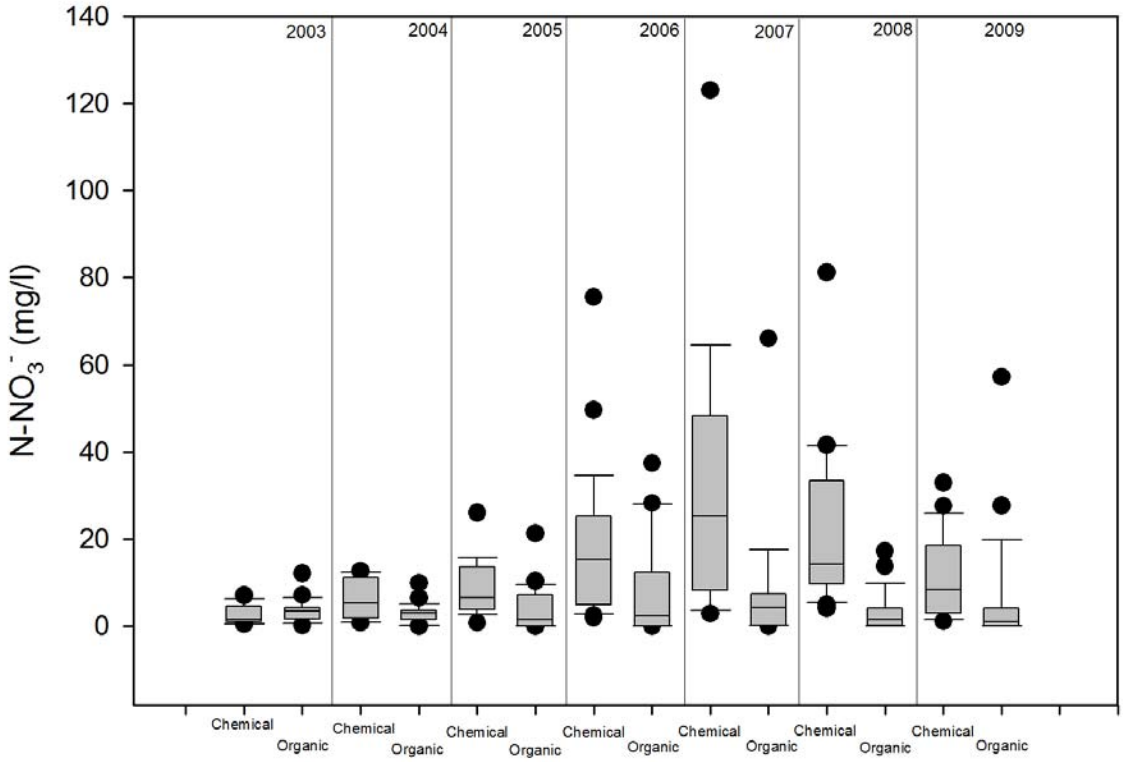

Figure 3. Box plot of soil-water N-NO^3 concentrations at 100 cm for each study plot for the years 2003-2009

CONCLUSIONS

On average, concentrations of soil water N-NO^3 collected at 100 cm beneath lawns treated with chemical fertilizer was higher than soil water collected beneath lawns treated with organic fertilizer or no fertilizer. Water collected beneath lawns treated with organic fertilizer were routinely found to be above the EPA drinking water standard of 10 mg/L even though these sites received less than a third the amount of nitrogen as the lawns treated with chemical fertilizer. However, the likelihood of concentrations of soil-water at one meter to exceed 10 ppm was lower for sites treated with organic fertilizer than it is for sites treated with chemical fertilizer, but the use of organic fertilizer alone does not guarantee lower nitrate concentrations or that the use of turfgrass fertilization alone may not raise groundwater concentrations above the drinking water standard for nitrate.

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Information Transfer Program Introduction

The Director and staff of the NYS Water Resources Institute undertake multiple public service and partnership activities. Most are conducted through multidisciplinary projects funded outside the Water Resources Research Act (WRRA) context. In order to couple WRRA activities to other NYS WRI activities, a portion of WRRA resources are devoted to information transfer through a partnership program with the Hudson River Estuary Program, dissemination of information related to emerging issues, and student training.

Director's Office Information Transfer

Basic Information

Title:	Director's Office Information Transfer
Project Number:	2009NY132B
Start Date:	3/1/2009
End Date:	2/28/2010
Funding Source:	104B
Congressional District:	22
Research Category:	Not Applicable
Focus Category:	Climatological Processes, Education, None
Descriptors:	
Principal Investigators:	Susan Riha, Andrew James McDonald, Stephen Shaw

Publications

There are no publications.

Hudson River Estuary Program Partnership

Funded by the NYS Department of Environmental Conservation (DEC), the program is guided by 12 goals as part of its Action Plan formed in 1996. These goals address signature fisheries, river and shoreline habitats, plants and animals, streams and tributaries in the entire watershed, landscape and scenery, public access, education, waterfront revitalization, water quality, and partnerships and progress. WRI and DEC work together to protect this rich estuary ecosystem that is a source of municipal drinking water, spawning grounds for migratory fish, habitat for bald eagles, and an excellent recreation area for boaters, anglers and swimmers.

Emerging Issues

Marcellus Shale: The NYS WRI director and staff continued to act as an objective information source in the contentious debate over the impacts of Marcellus Shale drilling in New York State. Some of this educational transfer was informal. WRI maintained a website with information on drilling and links to other credible sources. The WRI director as fielded numerous phone class and information requests from the media, public officials, and other interest groups. The director was also appointed as chair of a committee to review guidelines for development of shale gas on Cornell University land holdings.

The NYS WRI also undertook several more formal information transfer activities. WRI provided detailed written comments on the Supplementary Generic Environmental Impact Statement on Shale Gas Drilling, coordinating input from Cornell faculty. These comments were also made available to the public in the WRI website. The WRI director (Susan Riha) provided a briefing to congressional staffers on the topic in Washington, DC in February of 2010 as well as providing testimony to the New York State Senate Committee on the Environment in Albany, NY in October of 2009. WRI staff provided a seminar on water resource impacts of drilling at an information session for Cornell Cooperative Extension Agents in October 2009.

Climate Change Adaptation: An accurate understanding of regional changes in water resources due to climate change requires the synthesis of local climatology with knowledge of water infrastructure, water demands, and waterbody characteristics. Staff from the NYS WRI have been working in conjunction with climatologists in the Earth and Atmospheric Sciences Department at Cornell to merge climatological and water resource knowledge of New York State. This information is being used to shape an assessment of vulnerabilities of water resources in the state and possible adaptations to minimize adverse impacts. Such information is intended to be actionable in nature and to provide tangible suggestions for ways different entities (local government, state government, business) can adapt to climate change.

A summary of the work is currently posted in the WRI website. Preliminary findings were presented in October 2009 at the NYSERDA Environmental Monitoring, Evaluation, and Protection Conference, Albany Marriot, Albany, NY. Staff from the NYS WRI WRI has held meetings with the City of Ithaca and

Cornell Water plant staff to share relevant findings. Additionally, a formal report on the assessment's findings will be submitted to NYSERDA in May of 2010.

Student Public Service Activities

Students and interns are supported in several ways through WRI:

• Competitive Grants Program – in many cases, grants provide for at least one graduate or undergraduate student to work under faculty supervision on priority problems in New York State;

• Hudson River Estuary Program – internships are sought through the Student Conservation Association each year for at least one graduate, undergraduate or high school student to work with WRI staff.

• Direct support of student research – WRI staff also directly support undergraduate research by acting as mentors to undergraduates doing research as part of independent study projects. This year, WRI had two students working in projects, one related to Marcellus Shale and another related to climate change impacts on reservoir turbidity levels.

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	4	0	0	0	4
Masters	1	0	0	0	1
Ph.D.	2	0	1	0	3
Post-Doc.	1	0	0	0	1
Total	8	0	1	0	9

Notable Awards and Achievements